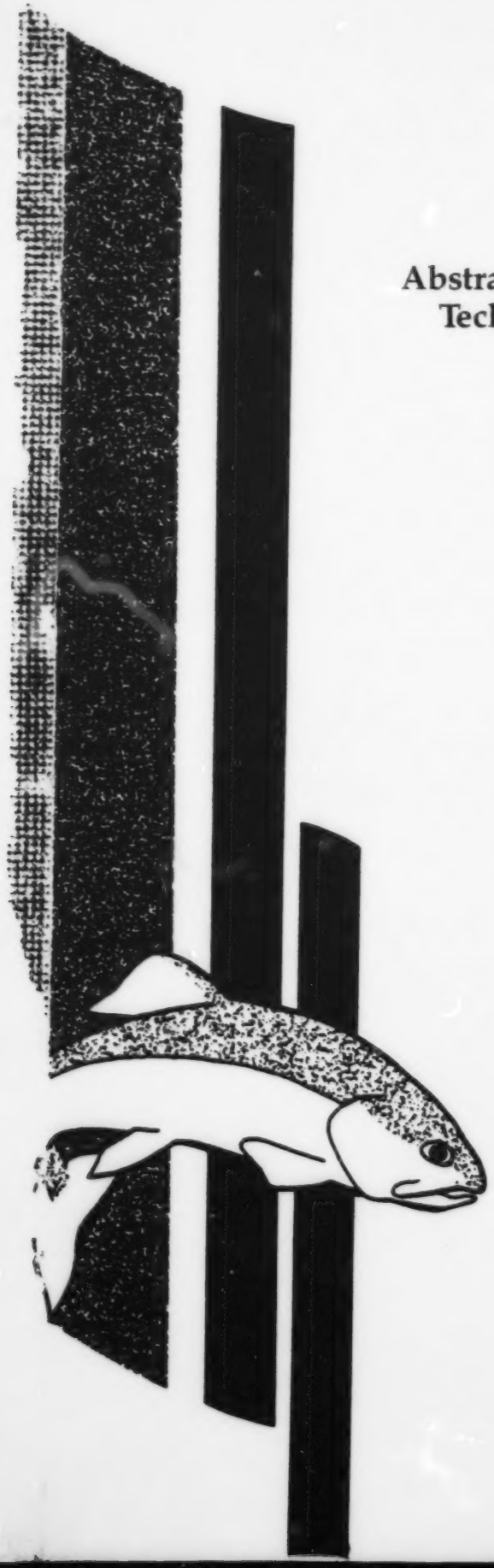

Abstracts of Fisheries Management Reports, Technical Circulars and Project Reports of the Fisheries Branch

by

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FISHERIES TECHNICAL CIRCULAR No. 91

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Province of British Columbia
Ministry of Environment, Lands and Parks

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ABSTRACT

Zaldokas, D.O. and D.L. Aird. 1991. Abstracts of fisheries management reports, technical circulars and project reports of the Fisheries Branch, 1987-91. Prov. B.C. Fish. Tech. Circ. No. 91:56p.

This publication is a compilation of 7 Fisheries Management Reports, 9 Fisheries Technical Circulars and 109 Fisheries Project Reports of the Fisheries Branch of the British Columbia Ministry of Environment. Only reports dated 1988 through 1991 were included. Where abstracts were unavailable summaries, introductions or titles were used. The compilation was assembled from the files of the Research and Development Section of the Fisheries Branch, and may be incomplete.

Fisheries Management Reports and Technical Circulars are reviewed and edited by the Fisheries Research and Development Section and are circulated to all Regional offices and other agencies in adjoining states and provinces. Review and editing of Fisheries Project reports are the responsibility of the author and circulation is very limited.

FISHERIES MANAGEMENT REPORTS

Ludwig, B.W., and R. Clough. 1989. Performance of trout fed a variety of feeds at British Columbia trout hatcheries, 1985-87. Prov. B.C. Fish. Manage. Rep. No. 93:22p.

The dietary performance and cost efficiency of production diets currently used for culturing trout at Provincial trout hatcheries were compared to several other diets available in British Columbia. Seven studies were conducted over three brood years at three different hatcheries. Six starter diets (BioDiet, Silver Cup Softmoist, Oregon Moist Pellet (O.M.P.), Ewos and Rangen's Softmoist) were tested. Of the starter and grower diets tested, BioDiet and BioMoist resulted in the best performance in terms of survival and production, while for the grower diets, Silver Cup provided the lowest cost per kg of fish produced. Several other diets including O.M.P., Ewos and Rangen showed promise but require further testing. BioDiet was recommended as the starter feed. Based strictly on production costs, the recommended grower feed would be Silver Cup, but a final recommendation cannot be made until a comparison of the relative survival in lakes for fish fed BioDiet and Silver Cup is completed.

Parkinson, E.A., J.M.B. Hume, and R. Dolighan. 1989. Size selective predation by rainbow trout on two lacustrine Oncorhynchus nerka populations. Prov. B.C. Fish. Manage. Rep. No. 94:14p.

Size distributions of prey from the lake and in the diet of large (>350 mm) rainbow trout feeding on O. nerka were compared in two lakes. In both lakes, O. nerka made up over 98% of the fish in both rainbow trout stomachs and midwater trawl catches. In Kootenay Lake, where there were no anadromous sockeye, kokanee (the non-anadromous morph) that were 100 - 200 mm fork length made up 42% of trawl catches, but in Quesnel Lake, which supports both kokanee and a large run of anadromous sockeye, trawl catches consisted on 95% age-0+ O. nerka (<80 mm fork length). Although the size of prey in Quesnel Lake (104 mm) was smaller than in Kootenay Lake (139 mm), most of this difference appeared to be due to differences in the size of the trout predators which averaged 540 mm in Quesnel Lake and 713 mm in Kootenay Lake. Few fry (<80 mm) were observed in the stomach samples of rainbow trout caught in either lake. In both lakes, the largest prey taken by rainbow trout predators were less than about 1/3 of the predator length.

Ward, B.R., and J.C. Wightman. 1989. Monitoring steelhead trout at the Keogh River as an index o stock status and smolt-to-adult survival: correlations with other data sources. Prov. B.C. Fish. Manage. Rep. No. 95:21p.

Population estimates of adult steelhead trout, obtained at the Keogh River on northern Vancouver Island, were compared to catch

statistics and underwater fish counts collected elsewhere in British Columbia. Also, survival rates from smolt-to-adult for Keogh steelhead were compared to rates obtained at another research station, Snow Creek, Washington. Similar trends were found in all comparisons. Angler catch of wild fish in the Keogh River and neighbouring streams was closely correlated with the run size estimates of the Keogh River adult steelhead (n=13). Annual catch of wild fish on Vancouver Island followed a similar trend as the winter run of the Keogh but the statistical correlation was weak unless years were sequentially paired (n=6). Representative winter-run streams to the south displayed catch statistics that weakly correlated with Keogh run sizes unless also sequentially paired. Of the larger rivers, there was close correlation between Nimpkish River catch, on northern Vancouver Island, but not Cowichan River catch on southern Vancouver Island, and Keogh run size. Underwater counts of steelhead in two summer-run streams had similar trends but failed to correlate with Keogh stock size, even with years paired. Survivals at the smaller Snow Creek in northwest Washington were similar to survivals obtained at the Keogh in 4 of 6 years, and differences in the other two years were possibly due to smolt size, handling effects and anomalous oceanographic conditions. Implications for future stock monitoring are discussed including the effects of introductions of hatchery fish and regulation changes on the validity of use of results from the Steelhead Harvest Analysis for interpretation of steelhead abundance.

Parkinson, E.A. 1990. An evaluation of adaptive management and minimal sampling as techniques for optimizing rainbow trout stocking rates. Prov. B.C. Fish. Mange. Rep. No. 96:14p.

Following a change in stocking rate of +40% Kentucky Lake and -40% on Alleyne Lake, length of age-3 rainbow trout declined by over 40 mm in Kentucky Lake and increased by over 50 mm in Alleyne Lake. Length at age 2 remained the same in Kentucky Lake but increased by 25 mm in Alleyne Lake. Higher stocking rates were associated with higher ages at harvest but variation in stocking rate had little effect on either the length of creeled fish or CPUE. An intense fishery, which rapidly removes recruitable sized fish was suggested to be the factor that decouples CPUE and fish size from stocking rate. High variation in CPUE and length at capture among years suggests that more years of data collection and larger management perturbations will be needed if the effects of changes in management policy are to be detected.

Oliver, G.G. 1990. An evaluation of special angling regulations for cutthroat trout in the lower St. Mary river. Prov. B.C. Fish. Mange. Rep. No. 97:19p.

Annual studies of wild westslope cutthroat trout (Oncorhynchus clarki lewisi) were conducted at the lower St. Mary River in the East Kootenay for a ten year period from 1980 to 1990. The effects

of progressive fishery regulation changes on the population were examined by underwater surveys and standardized angling techniques. Age and growth characteristics of the cutthroat population were also documented. After pollution abatement in the late 1970's, the lower river supported a largely unexploited fluvial trout population (adult spawning and juvenile rearing in tributaries; adult rearing in the mainstem river) with a mean length of 342 mm and a range from 260 to 440 mm. Estimated trout abundance was 118 per km of stream channel. Angling regulations in 1980/81 included catch and possession limits of 4 fish and a 'flyfishing' only restriction for approximately 18.5 km. In 1982, the total estimated population was 6400 cutthroat trout >20 cm. From 1984 to 1990, population trends were monitored using a 3.3 km "index section" of the river. In the presence of an expanding fishery, numbers of catchable wild fish declined from a peak of 96 per km in 1986 to 47 per km in 1990. Despite further restrictive regulations including a 2 fish catch limit, a bait ban, a winter trout closure and a 30 cm minimum size limit, the estimated population in 1989 was 2921 fish and mean size had dropped to 271 mm in contrast to 342 mm 7-8 years earlier. An experimental shift in 1988 to a catch and release regulations on a 13 km section of river resulted in an increase in the proportion of larger fish after a single year although further sampling and counts are needed to confirm this improvement. Only 34% of the population exceeded 300 mm in the section with a kill fishery, but in contrast 51% of the population were >300 mm within the trout release section, although with the small size (n=4,2) a difference could not be statistically confirmed. A comparison of counts in a 4 km catch and release "index site" after two years however, indicated a significant difference as the percentage of trout >300 mm increased from 18% (prior) to 33% after regulation. Future intensive management options to improve the age structure, and thereby fishery quality, in the kill zone include catch-and-release or an increased minimum size limit of 35 cm. The latter would permit a small harvest of trophy fish and diversify the fishery.

Walters, C., J. DiGisi, J. Post and J. Sawada. 1991. Kootenay Lake fertilization response model. Prov. B.C. Fish. Mange. Rep. No. 98:36p.

This report describes a computer simulation model developed to make predications about the response of Kootenay Lake plankton and fishes to restoration of higher nutrient loading. The model was developed using the Adaptive Environmental Assessment (AEA) workshop process, where a team of scientist with programming experience works with an interdisciplinary participant group of scientists and managers to translate the ideas, data, and policy concerns of that group into a working model for quantitative prediction. While group ultimate aim of the AEA process is to produce useful models for management, the initial aim in the workshop development is to clarify research priorities by directing attention to processes that are key to the model predictions but

are difficult to quantify, to discrepancies between historical data and model predictions, and to alternative hypotheses that would give the same predictions.

The model appears to give credible quantitative predictions of basic nutrient dynamics and budgets (phosphorus inputs, outputs, horizontal and vertical transport, epilimnetic concentration patterns, responses of concentration to fertilization). However, there are major uncertainties in the model relationships that translate nutrient concentrations into predictions of phytoplankton and grazing zooplankton production, the utilization of zooplankton production by Mysis relicta and kokanee salmon (Oncorhynchus nerka), and the effect of changing kokanee and Gerrard rainbow trout (Oncorhynchus mykiss).

With the best available parameter estimated, the model "reconstructs" recent population declines in kokanee abundance as a combined effect of reduced food availability (on growth, fecundity, and time spent in sizes vulnerable to trout prediction) and depensatory predation by trout. While the calculations attribute the reduced food availability partly to reductions in nutrient loading to the lake, the main impact is due to competition with Mysis for grazing zooplankters, particularly Daphnia. The model does not predict favourable responses of kokanee to lake fertilization; instead it predicts that fertilization will mainly enhance Mysis abundance and hence possibly even hasten the kokanee decline. Further, calculated prediction rates by Gerrard trout are presently high enough to cause further kokanee declines, and search efficiencies by the trout are high enough to cause even higher mortality rates, so the kokanee may soon be unable to recover even if their growth rates are substantially enhanced by fertilization.

Thus it appears that the key uncertainties now are about how the zooplankton community (grazer species and size composition, Mysis) will respond to fertilization. At least four processes were identified that may counter the pessimistic baseline prediction that fertilization will enhance Mysis to the detriment of kokanee: (1) cannibalism preventing further Mysis increase; (2) increased export of Mysis over the West Arm sill under fertilization conditions, (3) increases in predation on Mysis by kokanee and other fishes; and (4) reduced relative importance of Mysis predation on early spring development of grazing zooplankton populations, under more fertile conditions. One or more of these processes apparently does operate in Kennedy Lake, where K. Hyatt and K. Cooper have measured positive responses of both Neomysis and fish to fertilization.

All indications from the model are that the kokanee are now caught in a squeeze between competition and predation that will result in collapse of the kokanee population (and hence the prized Gerrard stock) if no action is taken soon to control either one or both sides of the squeeze. Control of predation could not easily

be accomplished by reduction in the Gerrard stock, due to its high recruitment rate per spawner, even if such reductions were politically feasible. Control of other predators is likely impractical for the same reasons. Hence it appears that the best management options are those related to kokanee productivity and competition with Mysis.

We conclude that it is still worthwhile to conduct a major fertilization experiment in the lake. It will be particularly critical during this experiment to closely monitor responses of Mysis (abundance, size, distribution, export to West Arm), grazing zooplankton (seasonal abundance, size distribution), growth of kokanee, and characteristics (size, number) of kokanee appearing in the stomachs of major predators - Gerrard trout, dolly varden (Salvelinus malma).

The situation with kokanee is now desperate enough, and the risk of its recovery being jeopardized by Mysis is high enough, that extreme options should now be considered to reduce Mysis abundance. These options include introduction of Mysis predators (such as deep water sculpin), use of bubblers or hydrodynamic oscillations to push Mysis toward the surface near the West Arm sill, and use of high fertilizer loads near the sill to reduce water clarity and induce Mysis to spend more time near the water surface (where they are vulnerable to export over the sill).

Parkinson, E.A. 1990. Impaired school formation at low density: A mechanism for depensatory mortality in sockeye salmon. B.C. Fish. Br., Fish. Mgmt. Rep. No. 99:17p.

A simple encounter model was used to simulate the process of school formation at dawn for different densities of juvenile sockeye salmon. The results suggest that the process of school formation may be severely inhibited by a low encounter rate among juvenile sockeye at the lowest densities commonly observed in natural populations. Encounter rates of predators with schools are insensitive to density because, under a given set of conditions, asymptotic school density is similar over a wide range of initial densities of prey individuals. Enhanced school formation may reduce predation risk at high sockeye density and provide a mechanism for the multiple equilibrium hypothesis of sockeye dominance cycles.

FISHERIES TECHNICAL CIRCULARS

Tredger, C.D., R.P. Griffith, and J.C. Wightman. 1989. Detoxification and decontamination of waters following chemical rehabilitation with Noxfish. Prov. B.C. Fish. Tech. Circ. No. 84:8p.

Water samples were collected from three lakes which were chemically rehabilitated in 1986 by the Province of British Columbia, Ministry of Environment, Recreational Fisheries Branch. Samples were analyzed for rotenone and the Noxfish diluent, to determine both persistence and rate of detoxification. Results indicated that both rotenone and the Noxfish diluent were essentially non detectable in water samples taken 7 months after fall treatments. The rates at which rotenone became non detectable ranged from 17 to at least 77 days. The Noxfish diluent reappeared after some period of absence in 2 lakes, including detection the following spring. It was recommended that routine water sampling occur where waters are used for domestic purposes, and that monitoring programs similar to this be continued and expanded to cover other piscicide formulations as used. Further programs to determine inert ingredient dissipation rates, pathways within lake systems for uptake and release of inert ingredients, and toxicity of inert ingredients to non target organisms are also required.

Billings, S.J. 1989. Steelhead harvest analysis, 1987-88. Prov. B.C. Fish. Tech. Circ. No. 85:45p.

Since 1966-67, at the end of the angling licence year, a questionnaire has been sent to a sample of anglers who fished for steelhead in British Columbia. Information was requested on their fishing activity and catch success and incorporated into an annual summary of steelhead sport catch. Over this time there have been considerable changes in licence sales, the number of days spent fishing, catch and release of steelhead, and freshwater angling regulations in B.C. In the 1987-88 season, 31,263 steelhead angling licences were sold, 11% of which were to nonresidents of B.C. Questionnaires were sent to 56% of licensees and a response was received from 55% of those contacted. Of the respondents, 74% reported going steelhead fishing and 60% of these 'active' anglers successfully landed a fish.

The provincial steelhead catch has increased significantly since 1982. In the 1987-88 season, steelhead anglers fished for 258,101 days in the province catching 153,489 fish. Wild steelhead made up the largest component of the catch at 124,348 fish; hatchery catch numbered 29,141 fish. Catch per angler day was 0.62. Provincial catch and effort were down from previous year's (1986-87) record highs of 188,417 fish and 279,505 days.

The increasing trend in steelhead catch in recent years is a combined result of increased stock abundance, sizeable returns of

hatchery fish to some rivers, and repeated captures of released fish. The Chilliwack/Vedder River was, once again, the most heavily fished stream in the province with 54,171 angler days. This river supported more than half of all the steelhead fishing activity in the Lower Mainland.

Reduced possession quotas as well as steelhead release regulations have resulted in a decreased proportion of the steelhead catch being kept. The ratio of fish kept has dropped from 63% in 1970-71 to under 13% in the last four years. Of the active anglers, 32% kept between one and five steelhead and only 2% kept more than five steelhead.

The Chilliwack/Vedder River reported the most fish caught (23,795) followed by Stamp/Somass/Sproat (11,401), Dean (9,505), Cowichan (9,151), Bulkley (7,717), and Skeena (7,707) rivers.

Overall, Vancouver Island reported the highest number of steelhead caught followed by the Skeena Mainland and Lower Mainland areas. Hatchery fish, in 1987-88, comprised 19% of the total provincial catch compared to 27% in the previous two years. The release ratio for hatchery fish averaged 70% compared to 94% for wild fish.

Sawada, J.O., and B. Warner. 1989. Abstracts of fisheries management reports, technical circulars, and project reports of the Recreational Fisheries Branch, British Columbia Ministry of Environment 1985-88. Prov. B.C. Fish. Tech. Circ. No. 86:55p.

This publication is a compilation of 9 Fisheries Management Reports, 18 Fisheries Technical Circulars and 96 Fisheries Project Reports of the Fisheries Branch of the British Columbia Ministry of Environment. Only reports dated 1985 through 1988 were included. Where abstracts were unavailable summaries, introductions or titles were used. The compilation was assembled from the files of the Research and Development Section of the Fisheries Branch, and may be incomplete. To aid in future publications of this kind, please ensure that a standard abstract is included in all reports.

Parkinson, E.A. 1989. Errors in ageing hatchery rainbow trout from small lakes in southern British Columbia. Prov. B.C. Fish. Tech. Circ. No. 87:7p.

The ability of readers to correctly age rainbow trout was tested using scales from hatchery trout marked and released as spring yearlings. After an initial learning phase, accuracy averaged 78% (range 73-85%). Neither the differences in accuracy among readers nor a tendency to underage was significant. Readers tended to make the same errors on individual scales, but most errors could be detected by discrepancies among pairs of readers. Errors in ageing had little effect on estimates of age structure or

length at age 2+ for this data set in which readers discussed the true age of each scale before proceeding to the next. Estimated age structure was 16% 1+, 57% 2+ and 27% 3+ and older, whereas the true age structure was 18% 1+, 50% 2+ and 32% 3+ and older. Estimated and true mean lengths at age 2+ were 304 and 301 mm, respectively. The small size of these discrepancies may be due to prior expectations and the continual feedback on true values for this data set.

Slaney, P.A., B.R. Ward, and L. Berg. 1990. A preliminary assessment of the effect of external abrasion on the smolt-to-adult survival of net-pen cultured steelhead trout. Prov. B.C. Fish. Tech. Circ. No.88:11p.

The effect of external abrasion of smolts on the return rate of maiden adult steelhead (Oncorhynchus mykiss) was assessed in a preliminary experiment at the Keogh River in south coastal British Columbia. Abrasion was defined by the incidence of scale loss, fin abrasion and opercular abrasion. Smolts with "low abrasion" (7,300) and "moderate abrasion" (10,300) were marked and released at similar sizes in the lower Keogh River during early May, 1984. Based on population estimates of returning adults in 1986 and 1987, the survivals of the low and moderate abrasion groups were not significantly different: 8.7% and 7.2%, respectively. Both groups returned at similar mean lengths after 2- and 3-ocean years. In addition, recoveries of adults as upstream migrants and downstream kelts combined were examined for differences between the two abrasion groups. Recovery rates from the low and moderate abrasion groups were similar: 4.0 and 4.3%, respectively. Corresponding recoveries of age 2-ocean steelhead were 2.1 and 2.3%, and for 3-ocean fish, 1.9 and 2.0%. The established level of disparity of smolt abrasion was apparently insufficient to cause differential returns of adult steelhead.

Ward, B.R., J.A. Burrows, and D.L. Quamme. 1990. Adult steelhead population size and salmonid migrants of the Keogh River during the spring, 1990. Prov. B.C. Fish. Tech. Circ. No. 89:29p.

Data obtained in 1990 from a fish counting fence installed on the Keogh River, a coastal stream located on northeastern Vancouver Island near Port Hardy, B.C., added to more than a decade of information collected on wild steelhead trout (Oncorhynchus mykiss). The total number of wild adults in 1990 was estimated to be 1,374; the sex ratio of which was 1:1.1, female to male. Mean lengths and weights were obtained for wild spawners (males 795.4 mm, 5.8 kg; females 764.9 mm, 4.9 kg), and mean lengths were obtained for wild kelts (males 764.1 mm, females 758.6 mm). Wild fish were estimated to comprise 72% and hatchery fish 28% of the total steelhead run on the Keogh River. The migration of wild adult steelhead was biased to the late-run component, which was relatively abundant, yet preliminary estimates of oceanic survival

were low for smolts which contributed to these returns. Preliminary returns of pen-reared smolts released early in May 1988 were compared to returns of fish which were released at the peak of wild steelhead smolts. After two years at sea, the later release returned at a rate twice that of the early release.

All smolts were captured. Total captures of wild fish were low compared to averages in past years: steelhead smolts, 3,133 fish (mean length 166 mm, mean weight 40.8 g); steelhead parr, 757 (103 mm, 11.6 g); coho smolts, 57238 (103 mm, 11.4 g); cutthroat trout, 205 (156 mm, 38.1 g); Dolly Varden adults, 721 (259 mm, 126.6 g); Dolly Varden smolts, 3,200 (145 mm, 29.7 g); Dolly Varden parr, 50 (110 mm, 11.1 g); and cottids, 1,388 (125 mm, 30.7 g). Peak migrations were May 7 (505 fish) and June 2 (362) for steelhead smolts; May 7 (76), May 8 (75) and June 12 (60) for steelhead parr; and May 7 (6,305) for coho smolts. From May 16 to June 13, a total of 1,423 steelhead smolts (45.4% of those captured) were manually tagged in the adipose fin with sequentially coded wire tags to examine the relationships of smolts' size, sex, migration time, and age and their subsequent survival and age-at-return. From May 1-31 a total of 22,715 coho smolts (39.7%) were coded-wire tagged, with tag numbers stratified into three time periods, as in 1988.

Balkwill, J.A. 1991. Limnological and fisheries surveys of lakes and ponds in British Columbia 1915-1990. Prov. B.C. Fish. Tech. Circ. No. 90:157p.

An index to the 2,905 lakes and ponds in British Columbia that have been surveyed by the Ministry of Environment, Inventory Section and other provincial and federal agencies. Surveys range from a partial to full reconnaissance level survey and some lakes may be surveyed several times. The surveyed lakes are listed alphabetically along with the type of information available on each lake.

Lirette, M.G. 1991. Angler harvest of lake char, kokanee and rainbow trout from Bridge Lake, 1990. B.C. Ministry of Environment, Lands and Parks, Fish. Tech. Cir. No. 92:19p.

Between May and September, 1990, the recreational sport fishery on Bridge Lake was surveyed. Aerial boat counts were used to estimate angler use at 10,133 angler days. Effort in the 1990 fishery increased 30% over previous years. A total of 699 anglers were interviewed throughout the summer at a fishing resort and a provincial campground adjacent to the lake. The average number of anglers per boat was 1.86 and the average angler hours per angler was 4.0. Anglers spent an estimated 40,533 hours fishing to catch 4,965 lake char (0.12/hour), 4,154 kokanee (0.1/hour) and 1,216 rainbow trout (0.03/hour). Ninety-six percent of the sport fish caught by anglers were killed. The estimated total harvest for lake char was 5,000 kg or 3.6 kg per hectare of lake surface area.

This was three to six times higher than the theoretical sustainable harvest for this species. Lake char in the creel and on the spawning beds averaged 45.8 and 45.3 cm fork length, respectively. Spawning lake char first mature at 7 years of age. They averaged 14 years old based on otolith samples and 9 years old based on scale samples. Ages have yet to be verified. Total lake char yield indicates over exploitation while age and growth data suggests a slow growing stunted population of lake char which has not been heavily impacted. A reduction in the regulated daily catch is recommended to offset increasing angling pressure on Bridge Lake. A total of eleven different food items were identified in 36 stomach samples of char from Bridge Lake. Zooplankton, and aquatic insects each occurred in 60% of the fish while only 8% of the lake char had eaten fish. The catch of kokanee and rainbow trout represented 5.0 and 0.9% of the fish stocked, respectively, into Bridge Lake. Management recommendations are discussed.

Abbott, J.C. 1991. Feeding, aggression and growth in juvenile steelhead trout (Salmo gairdneri). Prov. B.C. Fish. Tech. Circ. No. 93:110p.

Juvenile steelhead trout (Salmo gairdneri) compete for access to space and food, and the distribution of these resources within a population affects the relative growth and survival of individuals. Aggression is a means of competing for these limited resources. This thesis examines the causes of aggression and growth depensation (size divergence) in juvenile steelhead. The sizes of socially isolated juveniles diverged less with time than those of groups of interacting steelhead, although average growth rates were equivalent, indicating that the presence of competitors affects relative growth. A behaviourial mechanism resulting in unequal food acquisition or growth efficiency is indicated, as rations were in excess of requirements. Size-matched pairs of steelhead established hierarchies in which dominants grew 12.3% faster than subordinates although rations were equal. Therefore factors other than access to food (possibly stress) play a role in growth depensation. Groups of steelhead grew faster when the inter-feeding interval was reduced, even though daily ration was constant. Size divergence over time was unaffected at intervals ranging from 0.5 to 24-h. Marked increases in aggression were consistently observed following feeding. The magnitude of post-feeding peaks was inversely correlated with inter-feeding interval. Total daily aggression and frequency of various behaviours were unchanged. Learning of feeding times and anticipatory aggression were demonstrated by recording behaviour on the fifth day of a feeding schedule and continuing to monitor behaviour for one day after feeding was discontinued. Alpha and beta hierarchy positions were stable over a one week period.

Underwater observation of steelhead in hatchery production

facilities confirmed the occurrence of aggression. Various feeding regimes were presented to groups of steelhead in these facilities. No differences in growth, size divergence or fin damage were detected at four regular feeding intervals. Randomly fed fish showed less size divergence than regularly fed fish but had equivalent growth rates. This reduced growth depensation could result in a 6% increase in smolt production. Trout fighting tactics varied depending on the response of the opponent. Analysis of aggressive attacks and patterns of fin damage indicate that agonistic behaviour is the major cause of fin damage observed in culture facilities.

FISHERIES PROJECT REPORTS - RESEARCH

Ward, B.R. 1989. Trends and forecasts of winter-run steelhead at the Keogh River: Results from 1988. Prov. B.C. Fish. Proj. Rep. No. RD-18:6p.

Monitoring of the wild steelhead smolts and adults at the Keogh River continued in 1988. Smolt yield was low (3,324) from post-fertilization production. Size-at-age of smolts was similar to pre-fertilization years. The spawning population was large (1,800), and higher than expected based on the number and sizes of smolts that had left. The spawning population was comprised of a majority of fish hat had spent three years in the ocean (70% of the females and 55% of the males), with about 20% (twice the historical average) of the population comprised of repeat spawners. Very good conditions of survival in the ocean were indicated. Forecasted run sizes are for a continued abundance of spawners in 1989, but by 1990 the effects of relatively low smolt yield will likely result in below average returns of maiden fish. Adding to these runs will be repeat spawning fish and returns of about 1,000 and 600 adults in 1989 and 1990 respectively, from hatchery releases.

Ashley, K.I., and N.T. Johnston. 1989. Habitat Conservation Fund, Technical Progress Report (1988-1989). Salsbury Lake Fertilization Project. Prov. B.C. Fish. Proj. Rep. No. RD-19:17p.

Nutrient addition continued in the fourth year of a four-year pilot project, at a rate of 565 mg $P/m^2/5.4$ mo and 2,039 mg $N/m^2/5.4$ mo (8.5:1 N to P atomic weight ratio). Agricultural grade ammonium phosphate (11-55-0 and 12-51-0), technical grade mono-ammonium phosphate (12-61-0) and agricultural grade ammonium nitrate (34-0-0 and 34.5-0-0) were added weekly (April 26 to October 6, 1988) to a floating screen bottomed (153 um) box anchored in the deep end of Salsbury Lake. The nutrients were held in the epilimnion while dissolving, and sampling indicated they dispersed throughout the epilimnion. Summer phytoplankton densities were considerably higher in Salsbury Lake (2.1-15.5 µg/L Chl a) than in nearby control lakes (0.5-2.0 µg/L Chl a). Average (May-August) chlorophyll a concentrations in 1988 (8.0 µg/L) were similar to the past two fertilization years (11.9 µg/L, 1987; 6.9 µg/L, 1986; 3.6 µg/L, 1985), suggesting the lake is reaching a new equilibrium level of production. Maximum zooplankton densities were much higher in Salsbury Lake ($25,000/m^3$) as compared to the control lakes ($1,550$ to $5,300/m^3$). Mean size-at-age for wild and stocked kokanee has increased with duration of exposure to the fertilization treatment. Older age class (3+) rainbow trout are considerably larger in Salsbury Lake than in the two control lakes.

Ashley, K.I. 1989. The use of chlorine as a possible fish toxicant. Prov. B.C. Fish. Proj. Rep. No. RD-20:14p.

The use of chemical fish toxicants for coarse fish control is an accepted fisheries management practice in North America. In British Columbia the use of rotenone based fish toxicants is complicated by at least three factors: uncertainty of supply, cost escalations and increased concern about the effects and fate of chemicals used in lake rehabilitation programs. The need for chemical fish toxicants is valid in specific circumstances, and a literature review of approximately thirty chemicals used as fish toxicants suggests that chlorine may be useful as a limited purpose fish toxicant. Chlorine hydrolyzes to form hypochlorous acid (HOCl) when added to ammonia free water, which then dissociates and maintains an equilibrium with hypochlorite ion (OCl^{-1}). The relative concentration of each form is determined by the pH and temperature of the water. Chlorine combines with ammonia to form chloramines, and being a strong oxidizing agent chlorine will react with reducing compounds present in lentic environments (e.g., H^2S). Laboratory bioassays indicate chlorine is quite toxic to fish with 96 hr LC_{50} values ranging from 0.172 mg/L for rainbow trout (Salmo gairdneri) to 1.41 mg/L for black bullhead (Ictalurus melas). The primary toxicological mechanism of chlorine is oxidation of reduced iron (Fe^{+2}) in hemoglobin to methemoglobin (Fe^{+3}), resulting in an inability of the blood to carry sufficient oxygen and subsequent death by anoxia. At least three field tests have been conducted with results ranging from partial to complete kills, depending on the chlorine demand and concentration of residual chlorine in the water column. Chlorine may be a usefully fish toxicant in limited situations where conventional fish toxicants should not be used (e.g., drinking water sources) and the water body is quite small.

Tsumura, K., V.E. Blann, and C.A. Lamont. 1989. Progeny test of masculinized female rainbow trout having functional gonoducts. Prov. B.C. Fish. Proj. Rep. RD-21:5p.

Progeny tests conducted on masculinized female-only rainbow trout (XX males) having functional gonoducts indicate they produce monosex female sperm similar to other known XX male gonad forms. Occurrence of male and female offspring were compared in five XX male gonad groups separated according to shape, condition of the gonoducts and age of males. The shape of XX male testes ranged from abnormally globular and rounded to elongated. All XX male gonad groups had gonoducts that were occluded in three and functional in two of the groups.

Progeny identifiable for sex in the gonad groups with occluded gonoducts consisted of 100% female fish. Progeny identifiable for sex in the two groups with testes form similar to those in untreated normal males consisted of 86% and 100% female fish. Percent of progeny in which sex could not be determined at time of examination ranged from 3% to 12% in the different gonad groups.

Blann, V.E., and K. Tsumura. 1989. Rainbow trout broodstocks for coarse fish lakes. Habitat Conservation Fund Progress Report (1989-1990). Prov. B.C. Fish. Proj. Rep. No. RD-22:9p.

In the second year of the coarse fish broodstock project, a comprehensive evaluation of Blackwater River rainbow trout stocks was initiated. Seven lakes containing coarse fish were stocked with Blackwater River and Pennask Lake (control) stocks in equal numbers in May, 1989. Growth, relative survival and maturity of these two stocks were compared at the end of one growing season. Blackwater River stock grew up to 6% larger (t-test, $p<0.01$) than the Pennask strain in 6 lakes, but relative survival ranged from 1.2:1 Pennask to Blackwater in Gladstone Lake, to 9.8:1 in Pear Lake, at age-1+. Age-2+ Blackwater stock from the 1988 stocking in Garcia and Mathew lakes were 2.7 times larger, by average weight, than the Pennask strain fish. Relative survival of the age-2+ fish, however, was 4:1 and 3.5:1 Pennask Lake to Blackwater River stock, in Mathew and Garcia lakes. Coarse fish were found in gut samples of 1% of the total age-1+ Blackwater stocks, and 21% of age-2+ Blackwater fish. No fish were found in stomachs of Pennask Lake stock of either age class. Early sexual maturity appeared to be lake specific, not strain dependent, in this study.

Brood fish were collected from Bootjack, Tzenzaicut, and Tsuniah lakes. Progeny from these broodfish and Blackwater River stock will be liberated as 1+ fish along with the Pennask stock, for further comparisons, in the spring of 1990.

Parkinson, E.A. 1990. A framework for wild stock management of rainbow trout in small B.C. lakes. Prov. B.C. Fish. Proj. Rep. No. RD-23:10p.

A working hypothesis suggests that wild rainbow stocks in monoculture and coarse fish lakes represent two fundamentally different management situations. Within these two categories the ratio of lake area to stream spawning and rearing area is the key driving variable. In comparison with monoculture lakes, coarse fish lakes are hypothesized to have lower stock productivity and an exacerbated effect of size on survival. As a result, rainbow stocks in coarse fish lakes are more prone to population collapse and more dependent on streams as rearing areas for juveniles. If true, this implies that avoiding population collapse and protection of stream rearing habitat are key management problems on coarse fish lakes. In contrast, excessive juvenile recruitment and an insensitivity to high rates of exploitation should be more characteristic of monoculture lakes.

Blann, V.E., T.I. Godin, and K. Tsumura. 1990. Rainbow trout broodstocks for coarse fish lakes. Habitat Conservation Fund Progress Report (1990-91). Prov. B.C. Fish. Proj. Rep. No. RD-24:30p.

Performance of wild rainbow trout (Oncorhynchus mykiss) from the Blackwater River and Tsuniah, Bootjack and Tzenzaibut lakes (coarse fish lake strains) was compared to the Pennask Lake strain (monoculture) in eight study lakes having minnow and/or sucker populations. Two coarse fish lake strains and a control (Pennask) strain were stocked as yearlings in each study lake between mid-May and early June. Growth and relative survival of the strains were compared after a five month growth period.

Age 1+, Blackwater fish were significantly larger than Pennask fish in the four study lakes in which both were stocked. Tzenzaicut strain was significantly larger than Pennask in three of the five study lakes. Tsuniah Lake rainbow trout strain were significantly heavier, but not larger than Pennask strain fish in two of four lakes in which these strains were stocked. No significant size difference was found between Bootjack and Pennask fish in any of the four lakes in which both were stocked.

Relative survival was significantly higher for rainbow trout strains originating from a coarse fish lake than Pennask strain in five lakes, but was similar in three lakes.

Evidence of fish consumption was found at age 1+ in all rainbow trout strains originating from coarse fish lakes. Fish were not found in guts of Pennask trout until age 2+.

Slaney, P.A., and T. Godin. 1989. Sumallo River stocking evaluation: progress 1989. Prov. B.C. Fish. Proj. Rep. No. RD-25:27p.

The introduction of a resident strain of yearling rainbow trout into the Sumallo River was evaluated during summer to fall, 1989. A fence was operated to assess migration and fish were enumerated in the stream by use of underwater counts supplemented with electrofishing. A small proportion (9%) of the 7,000 fish that were stocked, migrated from the Sumallo into the Skagit River. Significant numbers of wild rainbow, comprised of mainly juveniles, also migrated suggesting that the Sumallo is providing recruitment to Ross Reservoir. Underwater census of hatchery and wild trout was not useful as a population enumeration technique because most fish moved deep into cover in association with the cool (10 C) summer temperature regime. Sampling of stocked rainbow trout in the fall indicated that growth was meagre. Further stocking should be deferred until the 1989 cohort, as well as returns from the 1988 stocking of Skagit migrant strain, are more intensely assessed in 1990.

Rosenau, M.L., and P.A. Slaney. 1991. A population assessment and stocking evaluation of rainbow trout in the Sumallo River. Prov. B.C. Fish. Proj. Rep. No. 26:85p.

An investigation of rainbow trout populations in the Sumallo

River, a major upstream tributary of the Skagit River, British Columbia, was conducted to assess the survival, size and abundance of two hatchery strains of rainbow trout (Skagit and Blackwater, stocked in 1988 and 1989, respectively) and to examine life history patterns of wild rainbow trout (Oncorhynchus mykiss) and Dolly Varden char (Salvelinus malma). A fish enumeration fence was operated to monitor emigrants and immigrants, and a mark-recapture survey was conducted on a representative 3 km section. Fishable sections were intensely angled and minnow-trapped, and growth patterns were analyzed from samples of fish scales. Few hatchery fish of either strain were captured in the Sumallo and Skagit Rivers; all were captured by angling and electroshocking and none by trapping. Both strains were stocked at a mean length of 134 mm, while average lengths at recapture were 315 (Skagit) and 194 mm (Blackwater); the larger increase of the Skagit strain probably resulting from accelerated growth in Ross Lake. Estimated numbers of Blackwater trout remaining in the Sumallo River during September, 1990 were very low (162 fish; 0.3% of all rainbow trout or 2.3% of those stocked). The downstream migration of wild rainbow trout was comprised of four age classes including 1+ (mean length, 97 mm), 2+ (126 mm), 3+ (149 mm) and 4+ (187 mm). Based on scale analysis, length-frequency distributions, and a comparison of age and growth with a nearby non-migratory fluvial population of rainbow trout (upper Skagit), most adult rainbow trout (>200 mm) in the Sumallo were migratory and had undergone a period of lake growth before returning to their natal stream to spawn or feed, or adfluvial-lacustrine. Back-calculations from scale samples indicated there was a strong positive relationship between size and survival, thereby the larger and older juveniles disproportionately contributing to the adult trout population. The density and biomass of juvenile rainbow trout and Dolly Varden charr during late September were 0.032 fish/m^2 and 0.53 g/m^2, and 0.040 fish/m^2 and 0.62 g/m^2, respectively, which are low compared to most trout streams. Extreme phosphorus deficiency (<1-2 ppb concentration in summer) and, secondarily, a relatively low summer temperature regime (ca. 10 C) are the main limitations to production of trout and charr of the Sumallo River. Management implications and options are summarized.

Tsumura, K., and T.I. Godin. 1991. Evaluation of rainbow trout strains in small coarse fish lakes. Three year summary: 1988 to 1990. Prov. B.C. Fish. Proj. Rep. No. 28:40p.

Growth and relative survival of progeny from wild rainbow trout (Oncorhynchus mykiss) strains originating from coarse fish environments have been compared to the standard Pennask trout strain (wild, monoculture) for three years. Mean size of "coarse fish" rainbow trout strains indicate faster growth in length and weight than Pennask trout during the first and second year after release into a lake, in most cases. However, recoveries of the "coarse fish" trout strains relative to the Pennask strain has been variable to date. This comparison may be confounded by differences

in mean size at release, differences in stocking density between years, behavioural differences that affect catchability and other unknown factors. Early male maturation does not appear to be a problem for strains compared over three years. The Blackwater trout strain matures extensively at age 3 and all have matured by age 4. About 50% of the Pennask trout also mature at age 3 but the remainder mature at age 4 or older. Proportion of rainbow trout with fish in the gut recovered at age 1+ ranged from <1 to 10% for the "coarse fish" trout strains. Coarse fish were not found in the gut of Pennask trout until age 2+.

Johnston, N.T., K.I. Ashley, and K. Tsumura. 1991. Survival, growth and yield of rainbow trout (Oncorhynchus mykiss) in the Twin Lakes, southwestern British Columbia, prior to lake fertilization. Prov. B.C. Fish. Proj. Rep. No. RD-29:31p.

Known numbers of marked, F_1 progeny of wild-stock rainbow trout were introduced as fall fry (1982-83) or yearlings (1984-89) into two adjacent, small, oligotrophic, coastal montane lakes with similar low concentrations of inorganic nutrients but different morphometries (z = 2.9 and 12.5 m). Survival, growth and yield were monitored by total removal and restocking. Minimum survival to age 2 was independent of size-at-stocking between 2 and 38 g, and did not vary between the two lakes. The average survival to age 2 was 42%. Instantaneous growth rates varied inversely with initial mean sizes and with initial standing crops, and were significantly lower in the deeper lake. Yield average 6.9 $kg \cdot ha^{-1} \cdot yr^{-1}$ in East Twin Lake (z = 2.9 m) and 2.9 $kg \cdot ha^{-1} \cdot yr^{-1}$ in West Twin Lake (z = 12.5 m). Power analysis of a proposed fertilization experiment indicated that four years of sampling would permit the detection of two-fold or greater yield with 95% power.

FISHERIES PROJECT REPORTS - FAIU

Sebastian, D.C. 1988. Steelhead production characteristics of the Babine River and tributaries, 1987. Prov. B.C. Proj. Rep. No. FAIU-09:74p.

A juvenile steelhead stock assessment and habitat inventory of the Babine River System at August, 1987, base flows was used to assess the vulnerability of the stock to proposed industrial development and potential over harvest. Wide ranges in fish densities and potential smolt production were attributed to differences in temperature, water quality and usable habitat. Steelhead fry densities in "useable" habitat were 10 to 30 times greater in non-glacial than glacial streams. The mainstem Babine River supported approximately 67% of the fry population and 80% of total smolt yield. Nichyeskwa and Boucher creeks were identified as the most important tributaries for steelhead production. At carrying capacity, 1,488,000 fry should translate to approximately 111,000 smolts and 13,400 adults before harvest for the system. Optimal escapement was estimated at 4,200 adults, including a 50% safety margin. On a provincial scale, Babine River is a moderately productive system. It appears the stock can withstand an average exploitation rate of up to 2:1 with no major impacts on full seeding requirements. Recommendations were made for habitat protection and further assessment.

Tredger, C.D. 1988. Okanagan Lake tributary assessment. Progress in 1987. Prov. B.C. Fish. Proj. Rep. No. FAIU-10:31p.

A three year program to assess fisheries enhancement opportunities in Okanagan Lake tributary streams was initiated in 1986 by the Fisheries Assessment and Improvement Unit. Initial investigations were undertaken on Mission, Powers and Peachland creeks. In 1987, the study included Mission, Powers, Peachland, Lambly, Shorts and Trepanier creeks. Objectives of the program were to assess current habitat conditions and stream fish production capacity relative to existing fish populations, and to identify factors limiting fish production, including streamflow. The methodology centred on a modified IFIM approach, in which weighted usable area at stream transects was calculated. Transect data was collected at each stream at flow stages encountered during the surveys, with the exception of Mission Creek, where hydraulic modelling information was available. Results are presented detailing stream width and weighted usable area at transects in each stream. Data is extrapolated to estimate total and usable stream area, and estimated capacity for kokanee spawning and juvenile trout rearing at the flow stages encountered. Recommendations for work to be conducted in 1988 are included.

Ptolemy, R.A. 1988. Low angler catch of steelhead from Vancouver Island's largest river. The Nimpkish - an analysis of a

paradox in smolt production. Prov. B.C. Fish. Proj. Rep. No. FAIU-11:76p.

Steelhead smolt production at present and full seeding levels is estimated from preliminary data on survival rates and space requirements of juvenile trout (pre-smolts) summarized from the literature and B.C. data files. Average maximum production of smolts for the Nimpkish River on Northern Vancouver Island was approximated as 0.5 to 0.6 smolts 100 m^{-2} total wetted area (late summer) for 3.5 year old fish. Poor smolt yield is related to cold stream temperature (older smolts), highly dilute water chemistry (T. ALK. = 10 mg/L, TDS = 13 mg/L) at baseflows, and limited suitable habitat for both fry and parr stages. The recognized coast-wide average is 2.0 smolts 100^{-2}.

The reported mean fecundity was unusually high at 5,800 eggs per female from a limited sample size (13) of large adults. The minimum egg deposition and adult run size recommended for naturally sustained, maximum production of smolts are 6.6 million eggs and 2,271 adults. Since the total stream area used by steelhead juveniles is near 632 ha by stream order analysis, the minimum required egg deposition is 104 eggs 100 m^{-2} which includes an addition of 50% due to environmental/measurement uncertainty. The required escapement to produce this deposition may be larger if the true eff-to-fry survival is less than 15% and/or the average fecundity more closely resembles the Vancouver Island average of 4,000 eggs per female. A worst case scenario would have the maximum ratio of catch (harvest):escapement as 0.4:1.0 for a population sustained by pristine habitat; the Nimpkish watershed has been extensively logged and has sustained the recreational activities of three large logging camps.

The potential carrying capacity was roughly estimated at 0.66 million fry and 0.21 million parr. Based on low and highly variable habitat saturation measures, the contemporary run size is roughly 1,400 adults. The minimum run size is expected to be closer to 3,600 adults at stream capacity. A pilot fry stocking project is detailed and habitat enhancement measures are discussed. A need to verify estimates of maximum juvenile abundance in ideal habitat can be satisfied by the control of recruitment in selected reaches. A further need to better quantify true fecundity is identified, which may result from future brood-stock collection.

Tredger, C.D. 1989. Fish production capacity in Mission Creek at 4 modelled discharge levels. Prov. B.C. Fish. Proj. Rep. No. FAIU-12:64p.

Weighted usable area and stream capacity for kokanee spawning and juvenile rainbow trout rearing was estimated at 4 discharge levels of fish production relative to current populations, and options for enhancement. Hydraulic conditions were simulated using the HEC-2 model at discharges covering a geometric series from 6 to

44% mean annual discharge (MAD). Results indicate the maximum capacity for kokanee spawning occurred at 1.42 m^3/s (22% MAD), and was approximately 330,000 fish. Current kokanee escapements were below carrying capacity at all flows simulated. Maximum capacity for juvenile trout was expressed at 0.42 m^3/s (6% MAD) for fry and 1.42 m^3/s (22% MAD) for parr. Application of theoretical survival biostandards to capacity estimates implied that potential trout migrant production to Okanagan Lake was limited by the amount and quality of parr habitat. Recommendations include a target summer/fall minimum flow of 1.42 m^3/s, spawning gravel improvements to Reach 1, and cover (boulder) installation to high gradient channelized reaches.

Sebastian, D.C. 1989. An analysis of rainbow trout (Oncorhynchus mykiss production in the Kettle River in south central B.C. Prov.B.C. Fish. Proj. Rep. No. FAIU-13:51p.

A fisheries investigation was conducted on the Kettle River upstream of Midway to assess habitat capability and the stock status of resident rainbow trout. Juvenile and adult populations were assessed using a combination of electrofishing and snorkelling during late summer of 1987 and 1988. The abundance of fry was extremely low in the mainstem (0-7 fish/100 m^2), while parr abundance appeared to be reasonable at sites with adequate cover (5-14 fish/100 m^2). Densities of catchable size fish were consistently low during both years, except for in the West Kettle River during 1987. The absence of older age classes indicates a problem with over harvesting. Below average summer flows during both study years reduced the proportion of suitable habitat for catchable size fish. The HQI method (Binns, 1982) suggested optimum densities of 6 kg/ha for the lower Kettle River, 12 kg/ha for the mid Kettle River and 21 kg/ha for the West Kettle River. Differences in habitat capability between stream reaches were related primarily to stream size and cover. HQI estimates suggest populations of 32,000 fish for the Kettle River and 14,000 for the West Kettle river, given an average catchable size of 150 grams (24 cm). The model indicated populations were at 20% or less of capacity in the main Kettle River. Fish sampling was inadequate to assess stock status in the West Kettle River. Pilot stockings of non-migratory interior stream stocks (i.e., Blackwater and Upper Dean) into the Kettle have been proposed to rehabilitate the fishery. A combination of stocking and more restrictive regulations are required to restore the trout fishery in the Kettle River. It is recommended that full scale stocking strategies be developed following results of the pilot stocking program.

Ptolemy, R.A. 1989. Effects of highway construction and mitigation on summer steelhead in the Coquihalla River, British Columbia. Prov. B.C. Fish. Proj. Rep. No. FAIU-14:210p.

The efficacy of habitat improvement techniques on a large,

high gradient, and volatile coastal river was examined during the summers of 1985 to 1987. Juvenile and adult summer steelhead trout (Oncorhynchus mykiss) abundance was estimated before and after construction of a 110 km/hr four-lane highway. The impacts of three major diversions and numerous highway encroachments on fish habitat were evaluated. Habitat mitigation employed over-sized (>1 m dia.) keyed-in rip-rap in channelized reaches forming revetments, purs (deflectors) and boulder groupings in a variety of configurations. Detailed habitat measurements, direct snorkel surveys, juvenile electrofishing and mathematical modelling of habitat (PHABSIM), calibrated with juvenile steelhead abundance densities, demonstrated that mitigation structures sustained higher densities of fish than untreated areas. However, mass bed load movement of sand (<6.3 mm dia.) from construction appeared to severely reduce fish abundance (65%) and growth by sedimentation and embedding of boulder habitat. A large net decrease in bed material size (d_{90}) was measured in reaches affected by channelization resulting in a reduction in parr habitat. None of the mitigation treatments employed were successful in re-creating high quality parr habitat. Negative long-term effects of construction in altered actions of stream increase with degree of habitat alteration through channelization and encroachments. Widespread impacts of sedimentation from road construction resulted in a severe reduction of habitat and stream carrying capacity from 1985 to 1987, reducing six year classes of steelhead production. Post study period monitoring suggests a slow recovery from sedimentation with improved fish abundance.

Tredger, C.D. 1989. Okanagan Lake tributary assessment. Prov. B.C. Fish. Proj. Rep. No. FAIU-15:23p.

Stream habitat quality and potential fish production was identified over a range of flow conditions in Lambly, Shorts and Trepanier creeks by estimating weighted usable width at established stream transects. Available habitat and capacity is reported relative to discharge levels. Limited kokanee spawning habitat was available in Lambly and Trepanier creeks at all flows sampled due to large substrate size. Significant potential exists for kokanee spawning in Shorts Creek. Rainbow trout production to Okanagan Lake appears limited by the amount of parr habitat in all streams studied. Potential production increased with flow over the range sampled.

Sebastian, D.C. 1990. Juvenile rainbow trout production in the Horsefly River, the largest tributary to Quesnel Lake, B.C. Prov. B.C. Fish. Proj. Rep. No. FAIU-16:62p.

Juvenile rainbow stock assessment was conducted on the Horsefly River system to determine current abundance and to estimate potential juvenile migrant production to Quesnel Lake using a habitat capability model for steelhead. The study involved a stock and habitat assessment during late summer of 1987, followed

by juvenile stock monitoring at index stations during 1988 and 1989. Assuming identical habitat requirements by rainbow trout and steelhead, approximately 237,000 fry and 54,000 yearling migrants potentially could be produced annually. Current fry abundance in the mainstem Horsefly ranged from near 50% during 1987 and 1988 to approximately 85% of habitat capacity during 1989. Application of provincial biostandards indicates adult production of 1,600 to 4,000 fish and estimates a minimum required escapement of 550 fish. Opportunities for enhancement and recommendations for further juvenile assessment are discussed.

Tredger, C.D. 1990. Small lakes index management: Analysis of 1989 results. Prov. B.C. Fish. Proj. Rep. No. FAIU-17:45p.

Summer angling effort was established on approximately 400 lakes in south central British Columbia in 1989 using aerial boat counts. Estimates are presented in graphical and tabular form in relation to lake size, potential fish production and stocking rates. These analyses are intended to provide a diagnostic tool for the management and evaluation of small lake fisheries.

FISHERIES PROJECT REPORTS - KOOTENAY

Gates, R. 1988. Gerrard Rainbow Trout Spawning Population and Egg Collection Data 1988. Unpublished M.S., B.C. Fisheries Branch, Nelson, B.C. Rep. No. KO-27.

In the spring 1988 the spawning population of Gerrard rainbow trout was enumerated and monitored. No fish were trapped for egg collection purposes this year due to early high water. A peak count of 340 fish was recorded.

Oliver, G.G. 1988. Winter circulation of Johnson Lake near Skookumchuck, British Columbia. Ministry of Environment anf Parks, Fisheries branch, Kootenay Region. Fish. Proj. Rep. No. KO-28.

Artificial circulation by means of an electric powered blower was undertaken during the winters of 1986 and 1987 at Johnson Lake near Skookumchuck, B.C. Winterkill was prevented during the first year of operation, yet unavoidable during the second year.

Despite an increase in the areal depletion rate, mean oxygen concentrations less than 3.4 mg/l were never encountered. Destratification lowered the mean temperatures of the water column to 1 - 2° C throughout the aeration period.

Electric powered installations were shown to be more cost effective than diesel applications where powerline costs are kept to a minimum.

Thorp, Grant N. 1988. Hill Creek rainbow trout brood stock collection and subsequent yearling production, 1988. Unpublished M.S., Fisheries Branch, Nelson, B.C. Fish. Proj. Rep. No. KO-31:12p.

In spring 1988 rainbow trout (Salmo gairdneri) returning to Hill Creek spawning channel were captured for egg collection. A total of 27 adults were collected, consisting of 24 native Hill Creek stock and three "trophy" Gerrard fish.

Approximately 17,260 eggs were collected from the Hill Creek stock. Eggs were incubated in the Hill Creek Hatchery and subsequent yearling production was approximately 12,000 resulting in a 70% egg to yearling survival rate.

Based on an estimated return rate of 2% from yearling to adult (excluding sport catch) 240 adults should return to spawn in 1993 when the fish are five years old.

Thorpe, G.N. 1988. Hill Creek spawning channel kokanee fry enumeration, Spring 1988. Unpublished M.S. Fisheries Branch, Nelson, B.C. Fish. Proj. Rep. No. KO-32:14p.

In fall 1987, approximately 103,528 kokanee (oncorhynchus nerka) entered Hill Creeek of which 73,437 spawned in the Hill Creek spawning channel. Resultant egg deposition in the channel was calculated at 9.91 million (Thorpe 1987a).

Subsequent fry production in the spring of 1988 was estimated at 4.35 million which represents a 43.9% egg-to-fry survival rate. The projected adult return in 1991 from stream and spawning channel production is 229,315. (Thorp 1987a)

Bell, J. 1989. Meadow Creek spawning channel adult kokanee enumeration and fry production evaluation 1987-88. Unpublished M.S. Recreation Fisheries Branch, Nelson, B.C. Fish. Proj. Rep. No. KO-33.

Escapement into Meadow Creek during fall, 1987, was estimated at 425,885 kokanee. An additional 250,000 adults ascended the Lardeau River in 1987; the lowest escapement ever observed on the system.

Spawning channel egg deposition approximated 22.7 million eggs. Mean fecundity was 191 eggs/female; the lowest ever recorded. Egg to fry survival was only 10.2 percent and as a result an estimated 2.3 million fry outmigrated from the spawning channel between April 20 and June 6, 1988.

The provincial hatchery program received in excess of 2.0 million eggs from Meadow Creek stock as a result of collection activities between September 14 and October 2, 1987.

Thorp, Grant N. 1988. Hill Creek Spawning Channel Adult Kokanee Enumeration, 1988. Unpublished M.S., Fisheries branch, Nelson, B.C. Fish. Proj. Rep. No. KO-34:19p.

Adult kokanee (Oncorhynchus nerka) returning to Hill Creek to spawn in the fall of 1988 were enumerated at a fence site located downstream of the Hill Creek spawning channel. A total of 291,612 kokanee were enumerated at this site of which 150,000 entered the spawning channel. A further 6,500 kokanee were visually estimated below this site yielding a total return to the Hill Creek system of 298,112 fish.

An estimated 27.3 million eggs were deposited into the Hill Creek system (natural creek and spawning channel). Production from the 1988 spawning effort is expected to generate an adult return of 378,000 in 1992.

A Bell, J, 1989. Meadow Creek rainbow trout and Dolly Varden hatchery production and stocking report, 1987 and 1988 year classes. Unpublished M.S. Recreational Fisheries Branch, Nelson, B.C. Fish. Proj. Rep. No. KO-35.

A total of 33,683 Gerrard yearling rainbow trout were liberated into Meadow Creek between mid-May and mid-June, 1988. All fish were identified with a combined left maxillary/adipose clip. Hatchery fish weighed 7.2 gm on average and measured between 65 and 117 mm. Egg to release survival was 54.9%.

The Gerrard rainbow hatchery program was abandoned in 1988 after abnormal spring freshet conditions caused the collection fence to fail.

A total of 5102 Dolly Varden fry were released into Meadow and John creeks between July 14 and August 25, 1987. John and Meadow Creek fish were independently marked with left and right maxillary clips respectively. An additional 1014 unmarked fry were liberated into the Kaslo River, near Keen Creek bridge, on August 4, 1987.

A total of 5102 Dolly Varden fry were released into Meadow and John creeks between July 14 and August 25, 1987. John and Meadow Creek fish were independently marked with left and right maxillary clips respectively. An additional 1014 unmarked fry were liberated into the Kaslo River, near Keen Creek bridge, on August 4, 1987.

A total of 3892 (96/kg) Dolly Varden fry were released into both Meadow and John Creeks on September 27, 1988. All fish were identified with a left maxillary clip. Hatchery fish weighted 10.4 gm on average and measured between 70 and 124 mm.

Bell, J. 1990. Meadow Creek spawning channel adult kokanee enumeration and fry production evaluation 1988-89. Unpublished M.S. Recreation Fisheries Branch, Nelson, B.C. Fish. Proj. Rep. No. KO-37.

Escapement into Meadow Creek during fall 1988, was estimated at 467, 895 kokanee. An additional 192,000 adults ascended the Lardeau River in 1988; the lowest escapement ever observed on the system.

Spawning channel egg deposition approximated 27.7 million eggs. Mean fecundity was 215 eggs/female with a 133-287 range. Egg to fry survival was 25.2 percent and as a result an estimated 7.0 million fry outmigrated from the spawning channel between April 18 and June 13, 1989.

The provincial hatchery program received in excess of 2.0 million eggs from Meadow Creek stock as a result of collection activities between September 16 and October 5, 1988.

Gates, R. 1989. Gerrard Rainbow Trout Spawning Population and Egg Collection Data. Kootenay Region, Nelson, B.C. Fish. Proj. Rep. No. KO-38.

In the spring of 1989 spawning population of Gerrard rainbow

trout was enumerated and monitored. A peak count of 363 fish were recorded for 1989. Also, in conjunction with enumeration a total of 36 fish were trapped for egg collection for the brood stock program at the Kootenay Trout Hatchery. A total of 14,000 eggs were collected using 24 of the trapped fish (15 males and 9 females).

Fleck, J.L. 1990. Kokanee Creek Spawning Channel Adult Enumeration 1988 and fry production 1989. Unpublished M.S. Fisheries Branch, Nelson, B.C. Fish. Proj. Rep. No. KO-39:17p.

Kokanee Creek is the largest of the three tributary streams to the West Arm of Kootenay Lake which support spawning kokanee. In 1984-1985 an artificial spawning channel was constructed to increase kokanee production.

During the fall of 1988, adult kokanee were enumerated and in the spring of 1989 fry production was measured. A total of 4,773 kokanee spawned in the spawning channel depositing 2,641,428 eggs in the gravel. A total of 636,594 fry were produced during the spring of 1989 resulting in an egg fry survival rate of 24.2%.

Thorp, G.N. 1988. Hill Creek spawning channel kokanee fry enumeration, Spring 1989. Unpublished M.S. Recreation Fisheries Branch, Nelson, B.C. Fish. Proj. Rep. No. KO-42:16p.

In fall 1988, approximately 298,100 kokanee (Onchorynchus nerka) entered Hill Creek of which 150,000 spawned in the spawning channel. Resultant egg deposition in the channel was estimated at 13.78 million (Thorp 1988a).

Subsequent fry production in the spring of 1989 was estimated at 7.92 million representing a 57.4% egg-to-fry survival rate. The projected adult return in 1992 from natural stream and spawning channel production is just over 500,000.

Thorp, G. N. 1989. Hill Creek rainbow trout brood stock collection and subsequent yearling production, 1989. Unpublished M.S. Fisheries Branch, Nelson, B.C. Fish. Proj. Rep. No. KO-44:17p.

In spring 1989 rainbow trout (Oncorhynchus mykiss) returning to Hill Creek spawning channel were captured for egg collection. A total of 33 adults were collected consisting of 30 native Hill Creek stock and three "trophy" Gerrard fish.

Approximately 10,000 eggs were taken from the Hill Creek stock. Eggs were incubated and reared in the Hill Creek Hatchery with subsequent yearling production of approximately 3,100 fish resulting in a green egg to yearling survival rate of 31%.

Based on an estimated return rate of 2% from yearling to adult (excluding sport catch) 62 adults should return to spawn in 1994 when the fish are five years old.

Thorp, G.N. 1989. Hill Creek Spawning Channel Adult Kokanee Enumeration, 1989. Unpublished M.S. Fisheries Branch Nelson, B.C. Fish. Proj. Rep. NO. KO-45:22p.

Adult kokanee (Oncorhynchus nerka) returning to Hill Creek to spawn in the fall of 1989 were enumerated at a fence site located downstream of the Hill Creek spawning channel. A total of 317,937 kokanee were enumerated at this site of which 150,000 entered the spawning channel. A further 5,500 kokanee were visually estimated below this site yielding a total return to the Hill Creeek system of 323,437 fish.

An estimated 32.43 million eggs were deposited into the Hill Creek system (natural creek and spawning channel). Production from the 1989 spawning effort is expected to generate an adult return of 522,000 in 1993.

Oliver, G.G. 1990. Investigations on the Status of Westslope Cutthroat (Oncorhynchus clarki lewisi) in the Lower St. Mary River (1980-89) Fish. Manage. Rep. KO-46.

The status of westslope cutthroat trout in the lower St. Mary River was summarized over a ten year period (1980-89) to describe the effects of progressive regulation change on an unfished to fished population. Initial investigations in the early 1980's showed a resident fluvial population with a balanced age structure and numbers (>200 m) of up to 118/km of stream channel. At that time, the mean size of fish was 342 mm and the population was considered relatively unexploited. Angling regulations in 1980 included catch and possession limits of 4 fish and a 'flyfishing only' restriction between Mark and Joseph Creeks. In 1982, the cutthroat population was estimated at 6405.

Population trends were monitored over a 3 km section of river from 1984 to 1989. In the presence of a fishery, numbers of fish dropped from a high of 96/km in 1986 to a low of 43/km in 1989. Despite further restrictive regulations including a 2 fish catch limit, a bait ban, a winter trout closure and a 30 cm minimum size limit, the population in 1989 was estimated at 2921 fish and mean size had dropped to 271 mm.

The results of a catch and release fishery on a 13 km section river one year after its implementation in 1988 showed improvement in age structure. Whereas only 34% of the population exceeded 30 cm in the kill fishery, it was shown that on average 51% of the population were greater than 30 cm within the trout release boundary.

Future intensive management options for the fishery including restorative stocking in tributaries as well as further restrictive regulations to improve the age structure are discussed. Life history and age and growth characteristics are also reported.

Oliver, G.G. 1991. The Trial Application of Contemporary Habitat Models to Predict Fisheries Capability in Selected Streams of the Kootenay Region. Fisheries Branch, Ministry of Environment. Fish. Manage. Rep. No. KO-47.

Stream capability was predicted for the lower St. Mary River and four major tributaries using a stream productivity model in conjunction with the weighted useable area concept. The productivity model incorporated total alkalinity and fish size to estimate near maximum densities. Depth, velocity and D90 were used to define the amount of suitable habitat within each drainage, upon which a final estimate of carrying capacity was predicted. Of the three variables measured, depth was found to be the most significant factor affecting juvenile and adult distribution. Of the total area available, only 21% of the mainstem river was suitable for adult cutthroat trout. 51.3% of the total area in tributaries was similarly useable by fry while 35.7 and 35.6% was useable by yearling and overyearling fish, respectively. Weighted useable area was not well correlated with biomass. However, sample size constraints limited the analysis (e.g 2 df for mainstem testing) and mainstem reaches may not have been at capacity.

Juvenile and adult trout densities observed in each watershed were considerably less than the numbers of fish predicted by modelling. The current density of adult trout in mainstem waters was estimated at 34% of predicted capacity. Similarly, juvenile densities in four tributaries ranged from 71.5 to 88.75% for fry and from 55 to 95% for parr of predicated capacity. A restorative stocking program in tributaries was suggested to initially boost fry and yearling densities to numbers near carrying capacity. Stream enhancement opportunities were also recommended to improve natural recruitment as well as increase the amount of suitable habitat for the older age-groups. Finally, this modelling approach was evaluated with respect to its applicability to other streams in the Kootenay Region.

CARIBOO REGIONAL FISHERIES REPORTS

Lirette M.G. and D. Tredger. 1991. Polley and Bootjack Lakes Creel Survey, 1990. B.C. Environment, Williams Lake, B.C. Regional Fish. Rep. No. CA 911:21p.

A creel survey was conducted on two popular sport fishing lakes in the Cariboo, Polley and Bootjack lakes. Between June 2 and September 2, 1990, 407 anglers were interviewed and 151 rainbow trout were sampled to provide information on the recreational fisheries of these lakes. The number of boats angling on Polley and Bootjack lakes were counted from shore and aircraft to determine total effort. Anglers fished an estimated 7,891 hours (3,446 days) to catch 15,412 trout (11,825 harvested) from Polley Lake during the May to September fishery. Bootjack Lake anglers fished 5,670 hours (2,324 days) to catch 7,515 trout (5,829 harvested). The trout captured from both lakes averaged 290 mm (145 to 360 mm) and were mainly 4+ years old (2+ to 6+). Over 80% of the fish harvested appeared to have spent at least one year rearing in their nursery stream prior to migrating to Polley and Bootjack lakes.

Doligan, R.B. and M.G. Lirette. 1991. Fisheries Assessment of Upper Maud Creek. B.C. Environment, Williams Lake, B.C. Regional Fish. Rep. No. CA 912:12p.

An exploratory assessment of juvenile rainbow trout in the "upper" Maud Creek drainage was conducted to determine current abundance and provide estimates of potential migrant production to Maud Lake. Rainbow trout fry were found in high densities at all sample sites in both Maud ($4.3/m^2$) and Rudy Creeks ($3.2/m^2$). Collectively, the total population of juvenile rainbow trout was estimated to be in excess of 110,00 fish. Gill net sampling for rainbow trout in Sandy Lake confirmed the presence of sport-fish in this lake. Water quality and quantity requirements to protect the fishery resource are discussed.

Lirette, M.G. 1991. West Road (Blackwater) River air survey of angler use, 1990. B.C. Environment, Williams Lake, B.C. Regional Fish. Rep. No. CA 913:25p.

An air survey of angling use in the West Road River watershed was carried out between June 21 and September 17, 1990. Boats on fifteen lakes and boats/vehicles on or near seven sections of the river were counted on approximately eleven weekend days and nine weekday days. Mean boat count for weekend and weekdays varied for lakes and stream sections depending on their accessibility. Good access resulted in high weekend use while poor access to lakes or stream sections resulted in higher weekday use. Mean boat counts were used to estimate angler use in days fished. The largest fisheries were on Tsacha Lake (1843 angler days), Marmot Lake (1672 days) and zone 2 (1095 days) and zone 3 (1047 days) of the

Blackwater River mainstem. The total estimated use on the Blackwater River was 4,333 angler days. The air survey data provides a relative comparison of angler use between lakes and river section in the watershed. It also provides the means to monitor future changes in the various lake and stream fisheries of the West Road River. Survey costs and effectiveness are discussed.

Griffith, R.P. 1991. Blackwater (West Road) River Assessment of Existing and Potential Resident Rainbow Trout Production Downstream of Kluskoil Lake. R.P. Griffith and Associates, Sidney, B.C. for B.C. Environment, Williams Lake, B.C. Region Fish. Rep. No. CA-914:176p.

During the period of critical low flows in September 1990, an assessment was conducted of existing and potential fish production in the Blackwater (West Road) River drainage below Kluskoil Lake. Results were based on intensive field sampling and sophisticated analytical methodologies. Electrofishing in juvenile habitat resulted in the capture of 11 different fish species. Rainbow trout was the species with highest frequency of occurrence, followed by chinook salmon, the only other salmonid species captured. Non-salmonids were principally found in mainstem areas (Blackwater, Nazko, and Baezaeko rivers). Rainbow juveniles were found at few mainstem sites (and in low numbers), but were by far the most numerous species in the 12 smaller tributaries that were sampled. Based on production modelling, rainbow fry and parr densities in mainstem habitat were grossly below theoretical capacities. Similarly, standing stock of rainbow fry was well below respective capacity in most of the smaller streams sampled. In contrast, rainbow parr appeared to be near (or above) capacity in all of the smaller streams where they occurred. In terms of mainstem populations of catchable-size fish, various estimates indicate that the Blackwater system (below Kluskoil Lake) is functioning at about half its theoretical potential, based on production modelling for such populations. The cause appears to be lack of recruitment. Survival of rainbow fry seems low in mainstem habitats (due to non-salmonid predators and competitors), emphasizing the importance of older recruits (parr) from tributaries. All indications suggest that a limitation in suitable habitat for parr is imposing a similar limitation on mainstem recruitment, and ultimately the numbers of catchable-sized fish in mainstem areas (notably the Blackwater River). The principal limiting factor appears to be the severity of low flows in most tributary streams, exerting greatest impact on parr habitat. since the current level of mainstem recruitment appears to rely on all available parr production, all smaller tributaries (and their flows) should be afforded full habitat protection (even small producers). Habitat enhancement should focus on increasing the abundance/availability of parr habitat in tributaries by such means as barrier/obstruction removal and/or flow augmentation (if feasible). Various options are suggested.

LOWER MAINLAND REGIONAL FISHERIES REPORTS

Clark, B.J. 1988. Juvenile Steelhead Capacity of the Seymour River Mainstem, 1987. Ministry of Environment & Parks, Surrey. Regional Fish. Rep. No. LM147.

Low flow in September 1987 produced optimum mainstem habitat for steelhead fry and parr. Forty nine (49%) of the mainstem (213700m^2) was usable by steelhead fry, 69% (300900m^3) by parr. Estimated usable habitat was greater than reported in 1986 due to better sampling (greater number of transects; more accurate equipment).

Maximum fry and parr capacities for the Seymour mainstem were estimated at 153,864 and 75,225 respectively.

At optimum fry densities the Seymour could produce 923 adult steelhead. Optimizing parr habitat could result in adult escapement near 3600 fish.

Wide variations in seasonal flows probably limit both fry and parr production in certain years.

Clark, B.J. 1988. The Enhancement of Summer Run Steelhead in Silverhope Creek: Progress in 1987. Regional Fish. Rep. No. LM149.

The summer run steelhead fry populations of Silverhope Creek have remained at optimal densities since 1984 and are capable of supporting adult returns of 400 fish without hatchery augmentation. Any change in channel form or harvest rates could effect the equilibrium.

Ninety (90) percent of fry density variation between sample sites can be explained by the depth and velocity of the channel. Steelhead parr densities are effected by depth and velocity as well as boulder cover (D90) and the sand component.

Future studies would be repetitive and it is recommended the annual assessment of Silverhope juveniles be discontinued.

Neuman, H.R. 1988. Skagit River and Ross Reservoir Fisheries Management Plan. B.C. Ministry of Environment. Fish and Wildlife Management. Regional Fish. Rep. No. LM150:40p.

This management plan outlines fisheries management objectives, strategies and activities for the Skagit River and Ross Reservoir for the next five years. The recent international agreement not to flood the Skagit Valley and the establishment of an endowment fund administered by the Skagit Environmental Endowment Commission has secured recreational development in the valley. Recreational use

is expected to increase considerably over the next five to ten years and if uncontrolled poses a threat to the Skagit River fishery. For this reason fisheries management objectives and strategies must be clearly identified and activated planed to achieve them.

The primary objective of this plan is to maintain the quality angling experience on the Skagit River and protect and enhance wild fish stocks. Strategies concentrate on managing angler use by controlling physical access, enhancing fish stocks, reducing reservoir harvest, assessing habitat improvement opportunities, and stocking the Sumallo River.

Fisheries management must be coordinated with the Washington Department of Wildlife. The fish stocks common to the Skagit River and Ross Reservoir and the international fishery on the reservoir require that the system the system to be managed cooperatively for the benefit of both Canadians and Americans

Funding assistance is required from the Skagit Environmental Endowment Commission for successful management of the Skagit River and Ross Reservoir fisheries.

Scott, K.J. 1990. Results of the 1988 Mail Out Survey of Seymour River Anglers. Ministry of Environment, Fish and Wildlife Management. Regional Fish. Rep. No. LM154.

A questionnaire was mailed to one in five people (227) who had obtained a Seymour watershed access permit for fishing since March 1986 (periods for which records existed). The main purposes of the survey were to: profile recreationists that have been using the upper river restricted access area; determine their perception of use levels; and solicit opinions on the importance of various attributes affecting their fishing experience and proposed management strategies for the Seymour River sportfisheries. A follow-up telephone survey was conducted to assess the affect of non-response.

Excluding 26 non-deliverables, half (102; 51%) of the remaining 201 people on the mailing list responded with completed questionnaires. Six (6%) were from hikers and the remaining 96 (94%) were from Seymour River anglers. Seventy six percent of the anglers who responded fished the Seymour more than 3 times per year and 70% spent most of their time fishing in the upper watershed. The non-response survey indicated that the results of this study were biased toward seasoned anglers who have fished the Seymour a lot.

Respondents reported a low average number of encounters per day with other anglers indicating an extremely light use level in all zones. Attributes of the Seymour anglers were wilderness feeling, uncrowded conditions, scenic beauty anf solitude (in that

order). Studies of sportfishermen in recreational situations with attributes similar to the Seymour indicated that anglers who fish in the Demonstration Forest will be very sensitive to factors that could reduce the quality of their angling experience. Survey results indicated encounters with hikers have less impact on an anglers fishing experience than encounters with too many anglers, water based recreationists (kayaking or rafters), or indirect impacts (litter or lack of fishing ethics). Mid day was the time period most anglers suggested for other recreational activities to occur to minimize impacts on angling.

While increased catch success was reported to be an attribute of lesser importance, the large majority of Seymour anglers did not agree with scaling down hatchery returns to reduce the incentive for fishing the river of crowding becomes a problem. Implementing special regulations was accepted in general, however, more than half the anglers disagreed with an all species catch and release, and a vocal minority of anglers that were obviously an established segment of the traditional angling clientele perceive gear restrictions (particularly fly fishing only) as preferential treatment of one group of anglers. Maintaining a permit system to monitor demand and if necessary limit use was seen as the most preferred method of regulating use.

Scott, K.J. 1990. Managing Aquatic Resource User Conflicts - Results From a Survey of North American Fisheries Management Agencies Ministry of Environment, Fish and Wildlife Branch. Regional Fish. Rep. No. LM155.

An explanatory letter and short questionnaire were sent to thirty eight agencies responsible for managing fisheries in Canada and the United States to request information on managing aquatic resource user conflicts. Responses were received from eight of twelve Canadian agencies and fifteen of twenty six American state agencies contacted.

The situations reported provided good examples of the variety of conflicts that can occur. Anglers often have adversarial relationships with boaters but they can also have mutual interests and interact co-operatively. Conflicts between various groups of anglers are also common. Establishing co-operative advisory committees, comprised of representatives from government agencies and public groups involved, has been the most effective way to investigate conflicts and develop solutions. Such committees must also be charged with recommending ways to implement their solutions (ie. gaining jurisdictional control of the user groups).

Development of area management plans through mediation between government agencies and concerned public groups has been effective to mitigate against conflicts before they start. If the public is involved in the development of the plan, they will be more likely to support the objectives and strategies in the plan because they

were part of the decision making process.

Temporal and spacial zoning were most often suggested to segregate users when necessary. Alternative times and locations available to each user group for obtaining a similar experience must be considered. This helps to assess the uniqueness and importance of a particular recreational situation to respective activities.

Education and awareness programs to inform users of problems they may not be aware of and to encourage courteous behaviour can help mitigate against user conflicts. Public meetings during the development of management plans also help to make user groups aware of the concerns of groups involved with other activities.

Clark, B.J. 1989. Steelhead Fry Densities of the Cheakamus River During October, 1988 and Resulting Adult Production. Ministry of Environment, Surrey, B.C. Fish. Rep. No. LM157.

Juvenile steelhead densities were at or over optimal densities in October 1988. The 1988 adult steelhead escapement was estimated at 534 fish. The number of adults required for optimal fry saturation was 256 leaving a biological surplus of 277 adult steelhead. Adult steelhead runs resulting from the fry and pre-smolts studied in 1988 are estimated at between 561 and 611 fish beginning in 1991.

Bech, P. 1989. Steelhead & Cutthroat Brood Capture 1987-88. A Summary. Ministry of Environment. Fish & Wildlife Management. Regional Fish. Rep. No. LM158.

This report summarizes the capture of steelhead and anadromous cutthroat trout brook stock for provincial and federal hatchery facilities in the Lower Mainland Region during 1987-88. A total of 263 steelhead and 303 cutthroat trout were captured at an estimated cost of $21,936.

Clark, B.J. 1989 Reconnaissance Report of Lang Creek and Its Spawning Channel, August 1988. Ministry of Environment, Surrey B.C. Fish. Rep. No. LM159.

No abstract.

Bengeyfield, W. 1990. Interaction Between Black Bass and Salmonid Populations: An Information Review. Ministry of Environment, Surrey B.C. Regional Fish. Rep. No. LM160.

A review of interactions between black bass and salmonid fishes was commissioned by the B.C. Ministry of Environment as a first step in the consideration of stocking largemouth or smallmouth bass for recreational angling in the Lower Mainland. Information sources were mostly primary and secondary scientific

publications, with some personal communications with professional fisheries biologists. Four major combinations of keywords relating to bass-salmonid interactions. Researchers at 12 agencies and fisheries organizations were contacted.

An overview of the general biology and habitat preferences of both basses is presented first, with sections on taxonomy, distribution, food, growth, reproduction, waterbody types, lows, depths, substrate and cover, temperature, movements, and water quality.

This survey found ten documented cases of black bass predation on salmonid fishes. Two references reported cases for both largemouth and smallmouth bass. One case involved spotted bass, a species not under consideration for stocking in B.C. Predation by largemouth or smallmouth bass on releases of hatchery salmonids was noted in five cases. Two well-documented cases in Lake Sammamish, Washington, and in the Columbia River, reported minor impacts on juvenile salmon migrations because bass were not feeding actively in the spring months. Only one case reported a serious problem caused by largemouth predation on summer rearing coho salmon in an Oregon coastal lake.

Accidental introduction of bass tapeworm into Lower Mainland waters should be avoided by obtaining certified bass stocks. These fish should be planted in a lake where the fishery can be informed regarding the dangers of illicit stocking.

Usher, J.B. 1989. Surveys of Selected Lakes in the Lower Mainland of British Columbia - 1989. Ministry of Environment, Fish and Wildlife Management, Chilliwack, B.C. Regional Fish. Rep. No. LM161.

Surveys were conducted on 8 lakes in Region II during the spring and summer of 1989. The following lakes were surveyed - Hicks Lake, Wood Lake, Devil's Lake, near Whonnock, Rolley Lake, Cultus Lake, Francis Lake, Lost Lake and Norton Lake near Upper Indian Arm.

The primary purpose of the surveys was to evaluate post stocking fish populations and to make recommendations for future stocking. Overnight sets of one or more gillnets was the method used to collect fish samples.

Information for each lake sampled including access descriptions, methods, catch rates, length and weight frequency histograms of game fish captured, photographs, general comments and management recommendations are presented in appendices 3 to 10.

Usher, J.B. 1990. Fish Samples Surveys of Selected Lakes in the Lower Mainland of British Columbia. Ministry of Environment, Fish and Wildlife Management. Regional Fish. Rep. No. LM161A

Fish were sampled from eight lakes in Region II during the Spring of 1990. The following lakes were sampled: Hotel, Richardson, Crowston, Waugh, Garden Bay, Klein and Trout. These lakes are all located within Management Unit 2-5.

The primary purpose of the sampling was to evaluate post-stocking fish populations and to make recommendations for future stocking. Overnight sets of one or more gillnets was the method used to collect fish samples.

Information for each lake sampled, including access descriptions, methods, catch rates, length and weight frequency histograms of game fish captured, photographs, general comments and management recommendations are presented in Appendices 3 to 10.

Whyte, I.W. 1990. An Assessment of Enhancement Opportunities in Schoolhouse Creek and Suter Brook, Port Moody, B.C. Ministry of Environment Fish and Wildlife Branch, Surrey B.C. Regional Fish. Rep. NO. LM162.

Enhancement opportunities were assessed for two tributaries of Port Moody Arm, at the east end of Burrard Inlet, B.C. Schoolhouse Creek and Suter Brook both support resident populations of cutthroat trout and possibly anadromous salmonids in their lower reaches; however, both streams are presently considered under utilized, particularly as a result of barriers that prevent the migration of anadromous stocks.

Salmonid populations and habitat were inventoried for each stream. Factors limiting production and enhancement opportunities were identified. Potential benefits that may result from habitat enhancement include creation of anadromous fisheries (cutthroat trout and coho salmon), improvement of the marine sport fishery in Port Moody Arm, increased opportunities for education and public involvement programs and increased public awareness of fisheries/environmental issues.

Bech, P. 1989. Steelhead & Cutthroat Brood Capture 1987-88. A Summary. Ministry of Environment, Fish & Wildlife Management, Surrey, B.C. Regional Fish. Rep. No. LM169.

This report summarizes the capture of steelhead and anadromous cutthroat trout brood stock for provincial and federal hatchery facilities in the Lower Mainland Region during 1987-88. A total of 263 steelhead and 303 cutthroat trout were captured at an estimated cost of $21,936.

Bech, P.B. 1989. Steelhead Rearing Potential of Upper Big Silver Creek. Ministry of Environment, Surrey, B.C. Regional Fish. Rep. No. LM197.

The purpose of this study was to determine the steelhead fry

rearing capability of reach two of Big Silver Creek and reach one of Clear Creek, a tributary. The two reaches provide a total of 35,038 m2 of suitable steelhead fry habitat, which could potentially support 17,371 1.5g fry. Small numbers of rainbow trout juveniles were captured by open-site electrofishing in both reaches. It is unknown whether these fish are migratory (steelhead) or resident. Adult steelhead presence should be confirmed by March/April snorkelling and/or angling. Before steelhead fry stocking is considered, present fish densities should be determined by closed site electrofishing.

Bech, P.B. 1990. Steelhead & Cutthroat Brood Capture 1988-89. A Summary. Ministry of Environment, Fish & Wildlife Management, Surrey, B.C. Regional Fish. Rep. No. LM198.

This report summarizes the capture of steelhead and anadromous cutthroat trout brood stock for provincial and federal hatchery facilities in the Lower Mainland Region during 1988-89. A total of 256 steelhead and 200 cutthroat trout were captured at an estimated cost of $25,707.00

Bech, P.B. 1990. Summary of standardized Skagit River rainbow trout length data, 1983 to 1989. Ministry of Environment. Surrey, B.C. Regional Fish. Rep. No. LM199.

This report summarizes and examines Skagit River rainbow trout length data from tagging studies, a test fishing project, and biological data collection projects from 1983 to 1989. The data is standardized to maximize comparability from year to year with the objective to detecting changes in the population's length characteristics. Examination of the standardized data shows no change in mean fish length in upper Skagit between 1983 and 1989, but suggests a trend of decreasing mean length in the Skagit since 1984, especially in 1988. The author recommends guidelines for future biological data collection projects to optimize data usefulness and minimize cost.

Knight, R. and H.R. Neuman. 1991. An aerial Survey of Angler Use on 137 Lakes in the Lower Mainland Region of British Columbia. Ministry of Environment Fish an Wildlife Management. Surrey, B.C. Regional Fish. Rep. No. LM200.

No Abstract.

Bech, P.B Cutthroat trout rearing potential of Elbow Creek upstream of the anadromous barrier. Ministry of Environment, Surrey, B.C. Regional Fish. Rep. No. LM201.

The purpose of this study was to determine the potential cutthroat trout rearing capability of Elbow Creek and its tributaries upstream of the anadromous barrier (2m high dam) and to

estimate the additional anadromous trout production that could be realized by providing fish passage over the barrier. The area upstream of the dam has an estimated summer surface area of 10,120m^2 of which 6,780m^2 is usable fry habitat and 3,610m^2 is usable parr habitat. This habitat is capable of rearing 7,322 fry and at least 304 parr, resulting in an adult cutthroat escapement of at least 55 fish. It is recommended that fish passage over the barrier be pursued or, alternatively, anadromous cutthroat fry be stocked upstream of the barrier.

Usher, J.B. 1990. Fish Sampling Surveys of Selected Lakes in the Lower Mainland of British Columbia. Fish and Wildlife Management. Regional Fish. Rep. No. LM202.

Fish were sampled from eight lakes in Region II during the Spring of 1990. The following lakes were sampled: Hotel, Richardson , Crowston, Waugh, Garden Bay, Klien and Trout. These lakes are all located within Management Unit 2-5.

The primary purpose of the sampling was to evaluate post-stocking fish populations and to make recommendations for future stocking. Overnight sets of one or more gillnets was the method used to collect fish samples.

Information for each lake sampled, including access descriptions, methods, catch rates, length and weight frequency histograms of game fish captured, photographs, general comments and management recommendations are presented in Appendices 3 to 10.

Knight, R. A Reconnaissance Survey of Rice Lake. Ministry of Environment. Lower Mainland Region, Surrey, B.C. Regional Fish. Rep. No. LM203.

No abstract.

Bech, P.B. 1990. Steelhead Rearing Capacity of the Mamquam River & Mashiter Creek. Ministry of Environment, Surrey B.C. Regional Fish. Rep. No. LM204.

The purpose of this study was to determine the steelhead rearing capacity and present steelhead populations of the reaches of the Mamquam River and Mashiter Creek presently accessible to anadromous fish. The study streams have an estimated surface area of 138,900m^2, of which 32,300m^2 is suitable fry habitat and 37,300m^2 is suitable parr habitat. Total estimated steelhead rearing capacity is 15,183 fry and 2,825 parr, which could potentially produce an adult steelhead run of 66 fish. Data from a single electrofishing site suggests that the study streams are operating at or near capacity, however additional data is required to confirm this and more electrofishing is recommended.

Knight, R.C. 1990. Chehalis Lake Evaluation. Ministry of

Environment, Fish and Wildlife. Regional Fish. Rep. No. LM205.

Gill netting of Chehalis lake stocks and a bio-physical inventory of tributary streams was conducted in 1988 and 1989 as a basis for a lake management plan. Dolly Varden, the main predator in the lake, were of good size and condition supporting a high use fishery. The major tributaries to the lake provide adequate recruitment of Dolly Varden to the fishery and are essential spawning areas. It is recommended all tributaries be closed to angling throughout the year to protect spawning and rearing Dolly Varden. A intensive creel survey is indicated in the future as angler effort increases because the potential for over-harvest exists.

Bech, P.B. 1990. Steelhead Fry Stocking Potential of Upper Big Silver Creek. Ministry of Environment, Surrey, B.C. Regional Fish. Rep. No. LM206.

The purpose of this study was to determine the steelhead fry stocking potential of reach 2 of Big Silver Creek and reach 1 of Clear Creek, a tributary. Electrofishing data suggested that a headwater stock of resident rainbow trout was utilizing 28% of the available fry habitat. It is recommended that 12,500 marked 1.5g steelhead fry be stocked in reach 2 of Big Silver and reach 1 of Clear Creek; that stocking densities be assessed and adjusted in the year following stocking; and that fish densities and habitat in reach 1 of Big Silver be assessed.

Knight, R.C. 1990. Biophysical assessment of the upper Cheakamus River, between Cheakamus and Daisy Lakes. Ministry of Environment, Surrey, B.C. Regional Fish. Rep. No. LM207.

In September, 1989 field work was undertaken to assess rainbow trout populations of the upper Cheakamus River and to identify recreational fishery potential and enhancement opportunities. This study was a continuation of assessment work that focused on the middle Cheakamus River in 1988. There is no significant recreational fishery potential on this section of the Cheakamus River be included in a single fisheries management plan and that no changes be made to current regulations.

Neuman, H.R. 1991. A Management Plan for Small Lake Fisheries in the Lower Mainland Region. B.C. Environment, Fish and Wildl. Management Surrey, B.C. Regional Fish. Rep. No. LM208:23p.

The small lakes fisheries resource of the Lower Mainland Region provides considerable recreational, educational and economic benefits to the people of the Region. However, the Lower Mainland is faced with an increasing demand for a limited fisheries resource. Growing human population and expanding industrial and urban development are placing increasingly heavy demands on a

limited resource.

This document is a five year management plan for small lakes in the Lower Mainland Region. The purpose is to guide fisheries mangers and to inform Regional and Program executive about regional issues facing small lake fisheries and strategies to resolve them. The plan is consistent with the mission ad objectives of the provincial Fisheries Program and the objectives of the Lower Mainland fisheries program.

Lakes in the Lower Mainland are relatively unproductive due to a combination of geology, climate and topography. Nutrients are low and spawning and rearing habitat for salmonids is often limited. Rainbow and cutthroat trout, Dolly Varden char and kokanee salmon are the predominant game fish. Fish in small lakes are subject to a variety of uses including angling, public viewing and commercial use (angling guides). Angling is the predominant use and is the primary focus of this plan. The Region offers a diversity of angling experiences ranging form urban to wilderness, from "put and take" catchable fisheries to catch and release trophy fisheries, from crowded to solitary and from relatively unregulated to artificial fly only.

The provincial Fisheries Program has four main strategic objectives:

1. Conserve Wild Fish Stocks
2. Protect and Manage Fish Habitat
3. Serve the Public Interests
4. Practice Strong Corporate Management

Priority is assigned to conserving wild fish stocks and managing fish habitat. For this plan, the first and third objectives have been modified slightly to properly address the Lower Mainland situation. Strategies for each objective are:

Objective: Conserve Native Fish Stocks

Strategies:
Prevent further decline of native fish stocks by increasing management activities directed at their conservation.

Protect threatened and endangered fish species.

Control the introduction and spread of exotic fish species in the Region.

Objective: Protect and Manage Fish Habitat

Strategies:
Develop Regional guidelines to protect fish habitat in small lakes.

Increase small lake inventory and assessment.

Improve habitat productivity in small lakes.

Objective: Provide for Public Use

Strategies:
Conduct public surveys on angler use and preference.

Increase the diversity of angling opportunities.

Increase the quality of angling opportunity and make more efficient use of existing opportunities to meet increasing angler demand.

Develop a coastal fish culture program.

Objective: Practice Strong Corporate Management

Strategies:
Increase planning on Lower Mainland small lakes.

Improve public communications delivery for small lake programs.

Implementation of the plan will focus on protecting and managing fish habitat and providing for public use. Native stocks will not be emphasized because they are not immediately at risk. On the other hand, there is a large public demand for angling which will be addressed through inventory and assessment, increasing the diversity and quantity of angling opportunity and improving habitat productivity. Full implementation of the plan is not possible without additional financial and human resources and will depend upon resource availability and Ministry, Program and Regional priorities.

Swiatkiewicz, V.J. 1989. Lower Fraser River White Sturgeon (Acipneser transmontanus) Studies from 1985-1987. Ministry of Environment, Fish and Wildlife, Surrey, B.C. Regional Fish. Rep. No. LM209.

The Fraser River white sturgeon fishery on the lower 100 km of river from Hope downstream to the estuary was studied from 1985 to 1987. This study included both tidal and non-tidal parts of the Fraser. Number of anglers obtaining free non-tidal sturgeon permits increased from 1,100 (1985-86), 1,500 (1986-87), to 2,000 in 1987/88. In 1986/87, sturgeon anglers fished 5,296 days, caught 3,951 sturgeon; of which 925 were killed. Most effort and catch occurred from the Mission Bridge (tidal boundary) upstream to the Harrison River. Average size of harvested fish was 121 cm and 18 kg. Fifty-four percent (54%) of harvested sturgeon were taken by ten percent (10%) of anglers.

A total of 1,500 sturgeon in this study area were tagged with Peterson disc tags form 1985 to 1987 and 24 were recovered. Recaptured numbers were insufficient to obtain a reliable population estimate of the Lower Fraser sturgeon population. More tags must be applied and more effort in recoveries is required to increase the degree of reliability of the estimate.

Preliminary analysis of length frequency catches of sturgeon between 75-150 cm indicates 10% mortality for fish in this size range. Radio tagging of nine sturgeon has yielded sturgeon movement information that is inconclusive.

Scott, K.J., J. den Breejen, and V.A. Lewysky. 1991. MS. An Assessment of the 1990 Skagit River Sport Fishery. Fish and Wildlife Management Lower Mainland Region, Surrey, B.C. Regional Fish. Rep. No. LM212:56p.

An on-site survey of the Canadian Skagit and Sumallo Rivers sport fisheries was conducted during the summer and fall of 1990. The primary ojective was to replicate a survey first conducted in 1986 to monitor changes in angler effort and success. Information on angler chatacteristics and social carrying capacity was also collected.

From July 1 to October 31, 1990, total angler effort was estimated at 12,271 hours. Overall, angler use in the 1990 season was similar to the comparable time period in 1986. While effort magnitude at the lower Skagit River was very similar between surveys, angling effort increased 39% at the Sumallo River and decreased 27% in the upper Skagit River.

Angler success of rainbow trout declined form 0.43 fish per hour in 1986 to 0.36 fish per hour in 1990. Comparisons of temperal and spatial distribution of angler catch rates showed almost uniform lower success than in 1986. The most notable exception was the lower Skagit River Section 1 in October 1990 (0.94 fish per hour).

The 1990 catch of 5305 rainbow trout was 5% less than for hte July 1 to October 31 period in 1986. The harvest of rianbow trout declined form 992 to 467 fish, or 53% less than in 1986. The overall release rate for trout in the 1990 season was 91% compared to 82% in 1986.

In 1990, 71% of the total catch of 106 Daolly Varden char were released compared to 63% of the total catch (115) in 1986. While anglers are releasing most of their fish, the small total catches of Dolly Carden in th esurveys indicates the Skagit River stock is quite small and may already be over-exploited.

Anglers interviewed in 1990 collectively exhibited similar demographic characteristics to 1986. However, more the 63% of the anglers had began fishing the Skagit since 1986 and 43% fished the Skagit for the first time in 1990. Experientail attributes (scenery, uncrowded conditions, wilderness feeling) were clearly the most important factors attracting anglers to the Skagit River. Use levels in 1990 in all three areas were well eithin social carrying capacity. In all areas anglers encountered fewer other anglers than they expected and 71% of the anglers assessed the use level to be "just right".

THOMPSON-NICOLA SUB-REGION SOUTHERN INTERIOR REGION

Chan, B.M. 1987. Chemical Rehabilitation of the Kane Lakes British Columbia Summary Report. Fisheries Branch, Southern Interior Region. Tech. Rep.

The Kane Lakes Rehabilitation Project was carried out between September 30 and October 2, 1986. Bioassay results indicated a concentration of 1.5 mg/1 of Noxfish brand rotenone (15% a.i) was sufficient to eradicate the Redsided Shiner (Richardsonius balteatus) population. In total, 5396 litres of rotenone was applied to the 6 lakes and associated drainage. Post treatment live cage monitoring indicated a complete kill. Water chemistry sampling to determine hydrocarbon and rotenone residue levels is ongoing. Restocking with Brook and Rainbow trout is scheduled for May, 1987. Reopening of the sportfishery is targeted for May, 1988.

Chan, B. 1989. Summary Report Deep Lake Rehabilitation Project. Fisheries Branch, Southern Interior Region. Tech. Rep.

The Deep lake rehabilitation project was carried out on October 14, 1987. Both Noxfish brand Rotenone and Fintrol brand Antimycin were applied in an attempt to remove an introduced population of Common Goldfish (Carassius auratus). Post treatment live cage monitoring indicated a complete kill. Restocking with Brook Trout (Salvelinus fontinalis) occurred in May, 1988. Growth rates in September, 1988 indicated an adequate size would be achieved for a May, 1989 opening.

Cartwright, J.W. 1989. A Guide to Fish Stocking in British Columbia. Fisheries Branch, Southern Interior Region. Tech. Rep.

The original "How and Why of Fish Stocking in British Columbia" was prepared in the mid-1960's and was intended as a guide for new staff confronted with the problem of stocking lakes.

This document is a revised version of the original, incorporating newly developed appendices of fish sizes and availability to better relect hatchery production capabilities as we move into the 1990's.

This "guide" deals with many of the subjective and objective elements which should be considered by regional fisheries staff when considering stocking a new lake, or reviewing past stocking lists or rationales. Discussed are two stocking formulas and the basic modifications to these formulas commonly used to determine how many fish should be stocked.

The two basic formulas discussed were originally developed for rainbow trout stocking into small, productive, interior lakes.

They should not be used for other species except, perhaps, for brook trout (char) or cutthroat trout in which cases they may provide a useful approximation of numbers needed for initial stocking.

Cartwright, J.W. 1989. Revised. A Guide to Fish Stocking in British Columbia. Fisheries Branch, Southern Interior Region. Tech. Rep.

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Caverly, A. 1991. Flood Damage to Fisheries Resources and Restoration in the Deadman Valley, 1990. Fisheries Branch, Southern Interior Region. Tech. Rep.

No abstract.

Caverly, A. 1991. Fall Run Steelhead Interception and Implications to Management of south Coast Commercial if Johnstone Strait, Strait of Juan de Fuca and Nitinot Areas, 1987, 1988, and 1989. Fisheries Branch, Southern Interior Region. Tech Rep.

No abstract.

VANCOUVER ISLAND PROJECT REPORTS

LIRETTE, M,G. 1988. Telemetric Studies of Summer and Winter Steelhead in the Stamp and Somass Rivers, 1984-85. Fish. Rep. No. VI 881:23p.

The freshwater migration behaviour of summer- and winter-run steelhead (Salmo gairdneri) were studied on the Somass River system between August, 1984 and May, 1985. Radio telemetry techniques were employed to monitor instream movements of steelhead and to determine time and location of spawning. Between August 21, 1984 and March 19, 1985, 271 steelhead were captured by angling the Stamp and Somass Rivers. Fifty-nine fish were held for broodstock, thirty-three were radio tagged, one hundred and sixty five were anchor tagged, six (8%) summer-run and 8 (4%) winter-run steelhead died from angling injuries. Tagged fish were comprised of summer- (n = 70), early winter- (n = 94) and late winter-run (n = 34) steelhead. Thirty-two tagged steelhead (16.2%) were recovered at Robertson Creek Hatchery. Seventeen tagged fish were recaptured by sport anglers. Angling recaptures varied between summer (7.5%), early winter (10.8%) and late winter (3.4%) tag groups. Wild steelhead were recaptured at over two times the rate of hatchery produced fish. One of the ten steelhead radio tagged in August (10%), five of the seven tagged in October (71%), seven of the eleven tagged in December (64%), and five of the five radio tagged in January/March (100%) were monitored to their spawning location. The average migration rate varied between radio and anchor-tagged groups of summer- (0.24 and 0.77 km/week), early winter- (0.42 and 1.12 km/week) and late winter- (0.64 and 2.44 km/week, respectively), run steelhead. Summer- and winter-run hatchery produced steelhead utilized the smolt release site (7-9 kms) and Roberston Creek Hatchery 25-27 kms) for spawning. Wild winter-run steelhead utilized areas above and below Stamp River falls for spawning (9-11 and 19-21 kms). The spawning location of wild summer-run steelhead was not determined.

SKEENA FISHERIES REPORTS

deLeeuw, A.D. 1989. Pallant Creek Steelhead 1986-87. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-56.

From November 1, 1985 to May 26, 1986, 148 adult steelhead were captured by study participants in Pallant Creek on the Queen Charlotte Islands. One hundred and forty three were tagged with anchor tags. Of these, 38 were recaptured once, and 3 were recaptured twice. Five fish were recaptured from the previous year's study. Of the total fish tagged, 67 (47%) were taken in March, with lesser numbers in December (13, or 9%), January (21, or 15%), and in February and April (5%). Sixty fish (42%) were taken in Zone 6, or the downstream reach of the river. Two-thirds of the recaptures were taken within the original tagging zone. Twenty seven of the 41 recaptures (66%) were taken within 20 days of their original tagging date. The time lag between first capture and first recapture ranged from 0 to 163 days. The five fish which were recaptured from the former season were all taken close to their original tagging date. Sex ratio favoured females slightly over males. The dominant age groups were 3.2 (33.3%), 3.3 (26.7%), 4.2S1 (20%), 4.3 (13.3%) and 4.2SS1 (6.7%). Average fork length was 71.6 cm and ranged from 43.2 to 91.4 cm. Two-and three-ocean males averaged 69.6 and 75.7 cm respectively. Three different multiple sample population estimation techniques calculated 374, 365 and 435 adults steelhead in Pallant Creek during the study. Results and the fishery are discussed.

deLeeuw, A.D. 1989. Observations on cutthroat trout of the Mosquito Lake system, Queen Charlotte Islands, 1986-87. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-57.

Resident juvenile and adult cutthroat trout (Oncorhynchus clarki) were sampled from February 1983 to July 1984 in Mosquito Lake and its tributaries on the Queen Charlotte Islands. Young of the year trout were found in two small (2-5 m width) tributary streams at average densities of 2.73 and 2.03/m^2 while in a larger (14 m width) stream the density was .36m^2. Parr utilized these streams at .27, .43. and .05/m^2 respectively. Fry were generally found in shallow riffles, while par utilized primarily pools. Fork length of lake fish averaged about 330 mm and ranged from 110 to 610 mm. Within streams trout lengths ranged from 20 to 145 mm. The most abundant age group in streams during the summer was 0+ (84%), followed by 1+ (13%), 2+ (2.5%) and some 3+ and 4+ (.5%). In the lake, age 5+ was the most numerous (30.7%) followed by 4+ (26.2%), 3+ (26.2%), 6+ (10.7%) and 2+ (6.2%). Of the 128 adult lake cutthroat sampled, 40% were males. Only 29% of all lake fish sampled were sexually mature, the majority of these were females. All fish in excess of 420 mm were mature females. Fecundity ranged from 617 to 742 for four females sampled. Results are discussed relative to other coastal cutthroat trout populations.

deLeeuw, A.D. 1989. Pallant Creek Steelhead 1986-87. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-58.

During the 1986-87 winter season 171 steelhead were angled and tagged by study participants in Pallant Creek, Queen Charlotte Islands. Of these, 39 were recaptured once, and 4 were recaptured twice while 1 fish was recaptured 3 times for a total of 44 recaptures. Fifty three percent of the catch was taken from the upper river during January and mid April. Migratory patterns were not detectable. The average number of days between recaptures was 39, and ranged from 0 to 167 days. Original tagging date strongly influenced probability of recapture. All November tagged fish were recaptured, while those subsequently tagged were recaptured in the following proportions: December 62% January 27%, February 19%, March 11%, April 6%, May 0%. Recaptures from other tagging years were generally taken within or near the month of their original tagging a year earlier. Three years of stream residency accounted for 90% of all readable scales examined while 61% had spent 3 years at sea prior to spawning. The dominant over-all age was 3.3% (49%) followed by 3.2 (22%), 4.3 and 3.1S1 (both 7%) and 3.1SS1 (5%). The remaining 4 ages accounted for 10%, while 19% were multiple spawners. Average length of all fish measured (152) was 75.1 cm, and ranged from 48.3 to 95.9 cm. Females (75.1 cm) were slightly larger than males (73.9 cm). The size of the 1986-87 run was estimated using the average of three multiple sample techniques and estimated at 489 steelhead with confidence limits ranging from 330 to 876 fish.

deLeeuw, A.D. 1989. Pallant Creek Steelhead, tagging and life history investigations. 1987-88. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-59.

An annual steelhead tagging and life history study was initiated on Pallant Cr., Queen Charlotte Islands in 1981. This report documents results obtained during the 1987-88 winter fishery. Between Oct. 20 and May 15, 160 steelhead were tagged, of which 36 were recaptured once, while 5 and 1 were recaptured 2 and 3 times respectively. An additional 8 fish from previous study seasons were recaptured. Fifty nine percent of the catch was taken from the upper 1.1 km of the river during Dec. and March. Time between initial capture and recapture ranged from 1 to 121 days and averaged 42 days. Seventy-two percent of recaptures occurred within the zone of original capture. The likelihood of recapture was considerably greater for early season tagged fish. Steelhead recaptured in this study from previous seasons were taken close to their original tagging date 1 or 2 years earlier. The dominant age group was 3.3 (46.3%) followed by 4.3 (20.4%), 3.2 and 4.2 (11.1% each), 3.1S1 (3.7%) and 3.2S1 and 4.2S1 (1.9% each). Fresh water age was dominated by 3. (63%) and 4. (33%) while ocean ages 2 and 3 accounted for 25.9 and 70.4% respectively. The total population was estimated at 466 fish.

deLeeuw, A.D. 1989. Pallant Creek Steelhead, tagging and life history investigations, 1988-89. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-59-B.

No abstract.

deLeeuw, A.D. 1989. Yakoun River Cutthroat. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-60.

No abstract.

Lough, M.J. 1988. Skeena Net Titles Survey. Preliminary Report of Native Food Fishing Effort on the Skeena River in 1987. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-61.

No abstract.

Spence, C.R. 1989. Movement of Skeena River steelhead trout through saltwater and Inland Fisheries, 1988. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-62.

Summer-run steelhead (Oncorhynchus mykiss) returning to the Skeena River system were radio-tagged to determine their rates of movement through commercial salmon fisheries near the river mouth. The run timing of individual spawning populations was also investigated as were riverine migrations through sport fisheries on the mainstem Skeena. Steelhead (n=140) were collected using a commercial seine vessel and either radio-tagged (n=55) or spaghetti tagged (n=80). Radio-tagged steelhead were monitored from aircraft or with stationary receivers as they entered freshwater. Additional data were obtained by examining the date and location of capture of tagged fish intercepted by the commercial fleet. The net rate of travel (km/day) towards the Skeena River was calculated from the times and distances between tagging and recapture locations. Only 39 (70.9% of total) radio-tagged steelhead were eventually accounted for, of which 6 were reported caught in the commercial fishery. The average rate of travel from points of tagging to the river was approximately 8 km/day. It was estimated that steelhead took 12 days to migrate through the entire commercial fishing area. Travel through the river mouth, where the highest gillnet catches of steelhead occur, took 2 -3 days. Rates of movement in the Skeena mainstem averaged 10.4 km/day for the area downstream of the Zymoetz River, and 20.2 km/day between the Zymoetz River and Bulkley River. Individual fish travelled as quickly as 32.0 km/day in the upper Skeena River beyond its confluence with the Bulkley. The study failed to outline differences in the run timing of separate stocks within the Skeena River drainage, largely because of limited sample sizes and the fact nearly all radio tags were disbursed over a two period.

Schultze, C.R., and Lough, M.J. 1987. Survival Rates of Fry released in the headwaters of Suskwa and Zymoetz Rivers. A Preliminary Assessment. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-63.

No. abstract.

Lough, M.J. and Schultze, C.G. 1988. Sustut River Steelhead. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-64.

No abstract.

Lough, M.J., R. Tetreau, and M. Beere. 1989. Douglas Channel Report. An inventory of seven Douglas Channel area streams: Giltoyees Creek; Triumph River; Kiltuish River; Weewanie Creek; Little Foch Creek; Big Foch Creek and Bish Creek. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-65.

No abstract.

Lough, J. 1990. Summary of the Kitimat River Anadromous Cutthroat stocking program, 1985 to 1990. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-66.

No abstract.

Hatlevik, S.P. 1990. The Lake Trout of Tutshi Lake; Life History and Preliminary Assessment of Annual Sustainable Yield 1987. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-67.

A limnological and fish sampling survey was conducted on Tutshi Lake in September 1987. It was determined that Tutshi was a large, cold, oligotrophic lake. A total of 96 lake trout (salvelinus namaycush) ranging in size from 13.0 to 88.4 cm and in age from 5 to 40 years were captured in 89 hours of gillnetting. Only four fish exceeded 50 cm, and there was some concern and speculation over the lack of larger fish in the sample. By comparison to other northern lakes surveyed in Skeena Region, lake trout from Tutshi were generally smaller. Growth rates were fairly rapid up to 11 years and 45 cm after which growth slowed markedly. Theoretically, Tutshi could provide an annual sustained yield of 1754 kg of lake trout or approximately 1763 fish weighing about one kg (average length 43 cm). Spring sampling is recommended to obtain a more representative sample of the lake trout population. Due to the vulnerability of lake trout to exploitation, more stringent angling regulations should be considered.

Tetreau, R and C. Spence. 1990. Survey of Native Food Fisheries for Steelhead in the Skeena River System, 1989. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-68.

Skeena River steelhead (Oncorhynchus mykiss) are subjected to commercial, native and sport fisheries as they migrate to their spawning areas. Standardized surveys are conducted to estimate fishing effort and catch in the commercial fishery (hail data, sales slips) and the sport fishery (eg. Billings 1988). In contrast, little is know about impacts of the native food fishery. Limited unpublished data from Department of Fisheries and Oceans (DFO) and Ministry of Environment files,along with cursory surveys by Morrel et al. (1985) and Lough (M.S. 1988) form the extent of our present understanding of this fishery.

Further study of the native food fishery and of steelhead catches in particular was conducted during 1989. The study involved two distinctly different areas and types of fisheries; part of the study focused on gillnetting on the mainstem Skeena, while the remainder was directed at the Moricetown Canyon gaff/dipnet fishery on the Bulkley River. The objectives of the investigations were:

1. to provide information on the spatial and temporal distribution of fishing effort;

2. to document catch with special reference to steelhead.

Beere, M.C. 1991. Steelhead migration behaviour and timing as evaluated from radio tagging at the Skeena River Test Fishery, 1989. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-69.

Between July 17 and August 16, 1989, Fisheries Branch personnel attended the Skeena River test (gillnet) fishery vessel which operated 6 km upstream of the Skeena River estuary. One hundred and thirteen steelhead trout (Oncorhynchus mykiss) were captured, of which 55 (48.7%) were dead when landed, 49 were radio tagged (43.4%) and 9 (8.0%) were anchor tagged. None of the anchor tagged fish were recaptured. Among 49 fish radio ragged, 7 (14.3%) were relocated by a stationary radio receiver 98 km upstream of the tagging site. These seven fish had an average migration rate of 7.0 km/day, less than that of seine caught fish for the same section of the Skeena River (10.4 km/day). One radio tagged fish was caught and killed in a native net fishery while another 3 were found dead near the original tagging site. The survival of steelhead released from gillnets is questioned.

Beere, M.C. 1991. Radio telemetry investigations of steelhead tagged in the lower Bulkley River, 1989. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-70.

Between September 11 and October 2, 1989, twenty three steelhead (Oncorhynchus mykiss) were radio tagged in the Bulkley River downstream from Moricetown Canyon. The objective was to assess the rate of migration through Moricetown Canyon. Tagged fish movements were monitored by stationary radio receiver stations until November 11, 1989, and by air from October 6, 1989 to May 24, 1990. Only five of 23 tagged fish migrated through Moricetown Canyon. Among these, migration rates ranged from 2.4 to 9.3 kilometres/day with a mean of 5.1 kilometres/day. Details of tagged steelhead behaviour are discussed.

Beere, M.C. 1991. Radio telemetry investigations of Babine River steelhead spring 1990. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-71.

Fifteen Babine River steelhead (Oncorhynchus mykiss) were radio tagged between 52 and 83 kilometres upstream of the Babine-Skeena River confluence of April 11, 1990. Tagged fish were tracked over a series of four aerial flights to determine time and location of spawning. Eleven of fifteen tagged fish migrated upstream to the Boucher Creek confluence area near the Nilkitkwa Lake outlet.

Beere, M.C. 1991. Survey of native food fisheries for steelhead in the Skeena River system, 1990. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-72.

Skeena River summer steelhead (Oncorhynchus mykiss) are harvested in commercial, native and sport fisheries as they return from the Pacific Ocean to their spawning areas each summer/fall. Although standardized surveys are conducted to estimate fishing effort and catch Statistics, DFO, Pacific Region) and sport fisheries (eg. Billings 1989), little data pertaining to the native food fishery has been compiled. Unpublished data from the DFO and Ministry of Environment (MOE) files, and cursory surveys by Morrel et al. (1985), Lough (M.S. 1983) and Tetreau et al. (M.S. 1990) describe some elements of the fishery.

Further study of the native food fishery and of steelhead catches in particular was conducted during 1990. The study involved two distinctly different areas and types of fisheries; part of the study focused on gillnetting on the mainstem Skeena, while the remainder was directed at the Moricetown Canyon gaff/jig/dipnet fishery on the Bulkley River. The objectives of the investigations were:

1. to provide information on the spatial and temporal distribution of fishing effort;

2. to document catch with special reference to steelhead.

Tetreau, R. and D. deLeeuw. 1991. Pallant Creek Steelhead 1989-90. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-73.

No abstract.

Hatlevik, S.P. 1990. A Mark and Recapture Study of Rainbow Trout Spawning in the Upper Nadina River, May 1988. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-74.

In May 1988 a mark and recapture study was conducted on spawning rainbow trout in the upper Nadina River, a few hundred metres downstream from Nadina Lake. The objectives were to determine if spawners migrated back to Francois Lake, and to obtain estimates of the spawning population.

A total of 269 fish were tagged and 68 were recaptured during the tagging project.

Various formulae estimated spawning populations of rainbow trout to vary from a minimum of 660 fish to a maximum of 1229 fish (95% confidence interval). Most spawning fish were either six or seven years of age and ranged from 35 cm to 45 cm. Females outnumbered males 3.8 to 1.

A total of 14 tagged fish (5.2%) were later recovered in the sport fishery in Francois Lake, while two (0.7%) were recovered in Tagetochlain Lake.

Tetreau, R. and D. deLeeuw. 1991. Pallant Creek Steelhead 1990-91. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-75.

No abstract.

Beere, M.C. 1991. Survey of native food fisheries for steelhead in the Skeena River system, 1991. Ministry of Environment Skeena Region. Skeena Fish. Rep. No. SK-76.

No abstract.

deLeeuw, A.D. 1991. A comparison of scale, finray and otolith derived ages in Dolly Varden Char, and Cutthroat trout. Ministry of Environment Fisheries Branch, Smithers, B.C. Skeena Fish. Rep. No. SK-77:8p.

Twenty-four Dolly Varden char from the lower Skeena River and 28 cutthroat trout form Mosquito Lake on the Queen Charlotte Islands were aged independently using finrays, otoliths and scales. For Dolly Varden char where only finrays and otoliths were used, age uniformity was obtained for only six fish. Age differences of one and two years occurred in eight cases each (16 fish) while the

remaining two fish were aged with a difference of three and four years. Average Dolly Varden age based on finrays and otoliths was 5.9 ad 6.7 years respectively and age class dominance was six years regardless of the method used. For cutthroat trout where all three structures were used for aging, age uniformity was not obtained for a single fish and in only 11 cases was there a pair of identical ages. Maximum individual age differences of 1, 2, 3, 4, and 5 years accounted for 18.5, 33.3, 26.6, 14.8 and 3.7% respectively. Average ages determined from finrays, otoliths and trout ages form these structures were 5, 4 and 3 years respectively. Implications of these discrepancies to the management of Dolly Varden and cutthroat trout sport fisheries are discussed.

de Leeuw, A.D. 1990. Babine Lake creel survey at Fulton and Pinkut Creeks, May - June 1990. Ministry of Environment, Fisheries Branch, Smithers, B.C. Skeena Fish. Rep. No. SK-78:6p.

Total angler effort and rainbow trout catch at Fulton and Pinkut Creeks in Babine Lake was estimated from May 1 to June 9, 1990 to document the catch of mature or pawner size fish. At Fulton, anglers fished for 313 days (average length = 2.39 h) and caught 269 rainbow trout none of which were considered mature. At Pinkut, anglers fished for 735 days (average length = 2.73 h) and caught 261 rainbow trout, 123 of which were in the mature size range (many fish were cleaned prior to survey). This catch was considered insignificant (2.7%) compared to the estimated total Babine Lake sport harvest of fish this size (3,000 - 6,000 fish) during 1985 and 1986. Based on the information collected during this survey, site specific restrictions such as complete closures at Fulton and Pinkut will not significantly reduce the catch of spawner size rainbow trout in Babine Lake as a whole.

de Leeuw, A.D. 1991. Observations on cutthroat trout of the Lakes River system, 1986, and implications for management. Ministry of Environment, Fisheries Branch, Smithers, B.C. Skeena Fish. Rep. No. SK-79:11p.

During 45 sampling days between April 14 and November 6, 1986, 810 cutthroat trout were tagged in the upper Lakelse River near Terrace, B.C. The majority were age four (34.3%) and five (25.4%), followed by three, six and two year olds at 17.6, 4.9 and 3.9% respectively. Repeat spawners comprised 13.7% of the sample. Average fork length of two, three, four, five and six year old cutthroat were 195, 235, 285, 355 and 383 mm respectively. A single seven year old fish was 420 mm. Cutthroat abundance during the study period was roughly estimated at 7000 fish (confidence limits 4977 to 21579). Tentative conclusions, based on both age compositions and abundance estimates obtained during this and earlier studies, suggest a stable cutthroat trout population. A consistent evaluation of the Lakelse Lake and/or River cutthroat trout population should be developed.

PEACE FISHERIES NORTHERN REGION

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